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Proceedings of the Michigan Engineering Society for

1889.

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THE MICHIGAN ENGINEERS' ANNUAL,

CONTAINING THE

PROCEEDINGS OF THE MICHIGAN ENGINEERING SOCIETY,

FOR 1889.

The Eleventh Annual Convention will be held in January, 1890, on call of the Board of Directors.

PRICE, 50 CENTS.

Proceedings of 1880 and 1881 are out of print. Later reports, 50 cents per year. Reports of 1886 and 1887 are bound together in one volume.

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REVIEW AND HERALD PUBLISHING COMPANY,
BATTLE CREEK, MICH.: CHICAGO, ILL.:
TORONTO, ONT.
1889.

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MICHIGAN ENGINEERING SOCIETY.

Papers and Discussions at the Tenth Annual Convention, held at Lansing, Jan. 22-24, 1889.

PRESIDENT'S ADDRESS.

Members of the Michigan Engineering Society:—

It was with much hesitancy that I assumed the office which by a majority of your ballots, was made imperative. And now to think of giving any direction to your thoughts or plans, seems like presumption itself. I am certainly very grateful for the honor conferred, and like a boy with his pocket full of goodies belonging to another, will promise "not to do so any more." At this our Tenth Annual Convention, held at the Capitol, where our first organization was effected, a retrospective view shows the wisdom of organization. The proceedings of other similar societies, nearly all formed since this one, evince a growing impulse toward improvement. So much is this true that a copy of society proceedings is received as a long-desired letter from a friend, and studied through and through, to learn what others are doing. These exchanges will in time make a useful addition to our libraries; and I recommend that they be carefully filed and bound. It is the active worker and searcher after facts, in these days, who stands foremost; and our Society, as such, and each individual member, should be no exception to the law. The duty is thrust upon us, and two words express the situation — *Do* or *die*.

It will not do to say we have done very well so far, and are satisfied with our attainments. "The mill will never grind with the water that is past." There is room enough up higher for the energetic surveyor and engineer, and he can always be improving from observation, study, and the teaching or experience of others.

And how better can we make advancement than by the association with others which this Society gives, and by making others' needs our own? We are not here to hear sweet words and dulcet melodies. The daily duties in office and field may well be sus-

pended; and while we profess to meet as business men, on business errands, a strict discussion of the program is our repast, and all the panacea we expect or need. Our doors are always open, and if a stranger or an honorable legislator walks this way, we shall not say him "nay." The only admission is, to such, a modest notice or recognition of our body, among other societies which grace the pages of the "Red Book." Perhaps, then, through a little official courtesy, and by keeping company with the Bee-keepers and Stock-breeders, we can make a decent appearance among some of our own Michigan people; and they may learn that nine years ago some of the lonely and disconsolate surveyors met around the dais of the pioneer room of the Capitol, and organized what has now grown to be the incorporated "Michigan Engineering Society;" that it takes hold of the live questions of surveying and civil and mechanical engineering, and we believe the more aid and encouragement it receives, the better for the State at large. Surely the grave questions of boundary lines and corners, the proper platting of villages, the location of drains and highways, the construction of bridges, the improvement of railways and rolling stock, the warming and sewerage of dwellings, the best management of steam for various purposes, and many other such topics, are directly connected with our substantial growth and progress as a State. What other profession does more? What other can better wield the destiny of any people? Its failures are far-reaching, and Panama follies are turned into a Pandora's box of all evil. Our own State is large, diversified, and calls for the best surveyors, engineers, and mechanics. Its progress even in the last twelvemonth, in railroad building, the platting of new villages, and the starting of manufactories calling for all kinds of machinery, is surprising. It would be the more so were it not that Michigan men have become accustomed to Michigan speed. We can realize how fast the driving-wheels go, by *dropping out of the car!* Are these statements too extravagant? Not intentionally. The facts bear us out. Nov. 6, 1888, Michigan cast 475,356 votes for presidential electors, which, at the usual estimate of population, would give 2,200,897, an increase in the last four years of 344,797. We said our State calls for the *best* surveyors and engineers, and we mean that each shall find his proper place in due time. The skimmed milk is in one jar, the cream in another. When the people learn by experience that work half done is dear at half price, and that good surveyors and engineers do not, on call, jump out of a ballot box, there will be greater advancement. The influence of this Society should be such as to say to every struggling one, "We will help you," and it should just as unmistakably discourage tramps, whether they travel along the highways with their earthly effects stowed in two old boots, or meander along the farm lines with compass and chain. What the State is doing at the Normal School, University, and Agricultural College to give a thorough

and complete course in practical, civil, mechanical, and mining engineering, and what it has lately commenced in the Mining School at Houghton, should be kept in vigorous progress. No parsimony should now cripple the good work being done. We are on the right track. The *hand* and the *brain* are *both being educated*, and by and by the young men who have gone out from these schools will have some of the shop dust to wipe off from their diplomas on to those of the kid-gloved kind who never make stir enough to raise a dust.

If the State can graduate from any of these institutions a class who would degrade intelligent labor, then just so far has it been unfaithful, and has squandered the public money. That the contrary is generally true, we believe, and the many responsible places filled by these graduates will abundantly prove.

We have reason for gratitude to the Giver of all good that our membership has suffered no loss by death since our last meeting at Kalamazoo, and for that general prosperity which prevails, and which has brought into greater requisition the engineers' services. We have had no disturbing strikes of laborers to stop engineering work, and be it said to our praise that there has been none of the trades-union spirit in which our members use the Society to make unusual and selfish demands; but all seem to be actuated by that spirit which shall better their knowledge in their respective branches of work and professional study, and thus make their united effort a public as well as a private good.

Our Secretary is to be specially commended for the neat and attractive annual report, and the several circulars and notices sent. This is a matter which requires good judgment and care to put it in the right hands for execution, and one which adds much to our proceedings. The present program brought out by the Executive Committee, in part, at their annual meeting in October last, and by the Secretary, after much correspondence, shows a most home-like and practical Michigan face. These topics are live ones, and are from those who are prepared to speak from experience. We hope it may afford sufficient variety. It has been said in our hearing that the engineers are now running this Society, and there is not a place for surveyors. If one would stop to think how dull is the music of the best hand-organ when played without intermission, and how impossible to sustain such an organization as this without due regard for each individual member, perhaps such a remark would not obtain. To my own knowledge, there has not been a session of this Society which did not afford ample opportunity to introduce any questions germane to our objects as set forth in the second subdivision of the Articles of Association.

It was thought best in the organization not to provide any standing committees as used to be our custom, and still is with similar societies, the reason being that a committee of several members was not easy to convene, and no one member wanted to take the

work alone, when there were others who should assist. I would therefore recommend that some topics be assigned to special committees, of one member each, who will be expected to do thorough work in the line assigned him, and report at our next annual Convention.

1. It would be well to have a special committee on *Questions of Practice*, with principal reference to surveyors' work, and any member during the year may address such committee freely with any question he needs light upon, and the decision of the committee shall be rendered subject to review by the Society. It is expected, however, that if the committee is not well prepared, an answer may be made after correspondence with other members. We well recollect the day when, isolated in the Northern Michigan woods, away from any surveyor whom we could consult, and lacking guide-books, such a correspondence with an able committee of such a State organization would have been very pleasant, to say the least.

2. A special committee on *Decisions*. This committee would be able to give us at our next Convention, a resumé of any important decision of State or United States courts bearing on boundary, or any matter of interest to this Society. One member making a speciality of this will be likely to bring together the most in that department.

3. A special committee on *Photography* as applied to Engineering. Of this subject we expect more will be said before the close of this session, but as it is now prominently before us, and is somewhat of a new feature, it would be well to prepare for next year's Convention early. The committee would be expected to interest any amateur photographer to make an exhibit, or by a little effort could himself make a loan of views for use a few days. The portraits of any eminent engineers would be a very pleasant feature for reference and study, while our next Convention was held. Many useful details would suggest themselves to the committee.

There may be still other subjects which could be best prepared by a special committee of one, and if any member will call them up, we will be pleased to have him.

The advertising pages of the Annual Report are well filled, and it suggests the thought that these dealers and those who make an effort to exhibit instruments at our Conventions, are especially worthy of patronage by the members of our Society.

The annual Convention, with its social greetings, is too infrequent. So, too, are the opportunities of our members to consult together, and improve themselves by this means. It would be more than we may reasonably expect to do to meet semi-annually, as the expense to some is now considerable, and more than it would be if all our attending members purchased certificates for reduced fare. Our Society presented the anomalous condition at the last Convention of having so many who were connected with

railroads, and thereby entitled to passes, that the others were compelled to pay full fare both ways. It would seem that on account of the good work this Society is doing for the railroads, and other engineering matters, some way might be devised so that every member could be assured of getting reductions to one and one-third fare. As it is, it reduces our attendance, and discourages those who come.

In connection with the idea of more frequent meetings is this; the failure of our State Institutions to benefit the people as they might, not *per se*, but because the people at large do not demand a different course. How little is known throughout the State what is being done and what is the *daily thought* at these institutions! The students know, and so do the Professors in charge. But both probably have too much to do already. We see results when a class is graduated. Then a sweltering crowd listen to music, and the sweet patter of words set to the latest rhetorical rhythm, and they go away to come again the next year, and so on. The graduates file out from this modern Parthenon, and Michigan people have the pleasure of reading a long list of names in the catalogues. Is it not wrong to give so many advantages to the few, at the expense of the many, when both might be subserved? We have seen that the population of Michigan is over 2,200,000. Now instead of limiting our State institutions to the service of the few who are able to attend them directly, a large number of our thoughtful, studious, and isolated people should be kept constantly informed of the current thought of these schools. Is there not some way in which these superheated bodies can send a little daily or weekly warmth to the distant regions of Michigan? or cannot the people be in closer contact with them by means of the press? Take the Surveying and Engineering Departments: How much is being worked out that would be useful to every one of this class? Both successes and failures should be spread abroad. You say that this is done by occasional reports and bulletins. And we answer, they *are too occasional.* Give these schools each a good active reporter, and the means to pay him, or turn some of the usual appropriations to a different purpose, and let us know by minute reports to the daily or weekly papers *just what they are talking about.* The people are the students, and they are sitting with their feet hanging from the rough back-woods benches, listening for something from these schools. Let these enlarge their borders, so that the whole State shall be their campus! The engineers are interested in this general question with its special application to their needs, and perhaps can use their influence with the "powers that be" to bring about these desirable conditions. If so, our meeting shall not be in vain.

With a most earnest desire for the good of every member, and our best wishes for a pleasurable session, I bid you, *Speed the Program.*

GEO. E. STEELE, *Pres.*

MUNICIPAL ENGINEERING.

To the President and Members of the Michigan Engineering Society: —

GENTLEMEN: Believing it to be the duty of each member of this Society to perform his quota of the necessary work, and responding to the request of the Secretary, I present herewith a paper on "Municipal Engineering."

Municipal engineering includes the construction, care, and maintenance of streets, sewers, water-works, bridges, etc., and, in a word, is intimately connected with all kinds of municipal public works.

The subject being of such general scope, it was found necessary, in order to keep this paper within proper confines, to generalize, rather than enter much into details.

In the contemplated improvement of a city by the grading or paving of its streets, the first step to be taken is the preparation and adoption of general plans, in order that, as these improvements are made from year to year, the several parts shall work harmoniously into the whole.

Before proceeding with the preparation of general plans, bench marks should be established throughout the city, with reference to some assumed datum line; levels should then be taken, extending over the entire limits of the city, and from these levels a topographical map be made in order that the engineer may intelligently prepare a grade map, or plan, for street improvements, or a plan for a general sewerage system; and all street improvements of a permanent nature should, thereafter, be made in conformity with the general plan.

In the case of sewers, after deciding upon the system to be adopted, whether a separate or combined system, by the aid of the topographical map the proper location of the main and lateral sewers can be decided upon, and no deviations should be made from said plan, except for very good reasons.

A question which will invariably confront the authorities of young cities which are about to make public improvements, is, "How shall the work be paid for?" Various cities have various methods. Some pay for the improvements by issuing tax receipts to the contractor, who is then supposed to collect the taxes for the improvement; others issue orders to the contractor, drawn upon a special fund created by assessment upon the property benefited, the orders, in some cases, drawing interest. Others, again, pay for the work in cash during the progress of, or upon the completion of, the work, the city realizing money for this purpose by the sale of its bonds running a certain number of years, and drawing a fixed rate of interest. This last method is the most economical for the city and its citizens, as it insures the contractor against loss

by failure on the part of some property owners to pay promptly their proportion of the cost of the improvement. The contractor will therefore not be required to put the amount of money into the work that he would were he compelled to wait for the collection of taxes before realizing anything from the job; and hence he will do the work cheaper. Not only this, but it gives a wider field for competition. It permits the contractor of limited capital to compete with the man who has a bank behind him. It gives better satisfaction to the persons who execute the work and to the persons who pay for it; to the persons who execute the work, because upon its completion and acceptance, they are paid all that is due them; and their interest therein ceases; to the persons who pay for the improvement, because they realize that they are paying far less than they would were the contractor paid in orders or tax receipts, thus compelling him to place his figures high enough to provide against loss and delay.

Where work is paid for otherwise than in cash, the party paying promptly is paying for the delinquency of his neighbor. For these and other reasons, improvements should be made upon a cash basis, and the adoption of such a system is recommended as being the most economical and satisfactory.

The question of the method of payment having been settled by the authorities, and the improvements decided upon, I shall discuss them under their respective heads, first, however, recommending the establishment of permanent marks or—

STREET MONUMENTS

of some imperishable material, by which to locate the street lines.

The particular location of these monuments is not so material, so long as a uniformity is observed in locating them with reference to the center or side lines of the streets.

A good plan is to plant a cast-iron post at the intersection of the center lines of all streets crossing one another. The size and shape of one form of post used by the writer, is shown in the accompanying sketch (Fig. 1). Weight, 15 pounds; cost, whatever you can get the casting done for, usually three or three and one-half cents per pound, including the drilling of a small hole in the cap, to mark the center.

The monuments are quickly and easily set. The point at which they are to be planted having been found, they are then driven by a heavy iron maul with wooden faces, care being taken to drive them straight, and the monument being kept to the line of each street by glancing over pins which have previously been set on the center lines. After driving the monument a few inches below the surface, measurements should be taken to the most permanent objects accessible, and recorded, in a convenient form for quick and easy reference, in a book kept for that purpose, and designated "Monument Book."

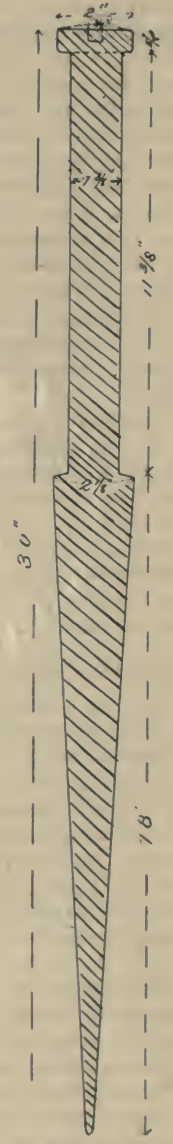

FIG 1

Street Monument

In recording the references, the writer uses an index book, indexing the east and west streets, and starting at the first street intersecting on the west, proceeding easterly, noting the streets in their order, to the east end of the street.

Each alternate page is ruled to five columns, leaving the intervening page blank for remarks; the last four columns on the first page are headed respectively "N. W.," "N. E.," "S. W.," "S. E.,' and refer to the direction in which the reference to the monument was taken.

The sample page given herewith, explains this more clearly.

HOYT.	N. W.	N. E.	S. W.	S. E.	REMARKS.
Water.....	....	47.9 f. post	.....	62.8 to br'k chim.	.....
Washington	....	59.4 f. post	.....	39.0 lamp post..	.....
Franklin...	45.8	28.65 basin	30.05 basin	46.55 bld'g	.....
Cass	....	.....	.....	.....	.....

Explanation: Hoyt St., which appears at the head of ths page, is an east and west street, and the index street, Water St is the first street intersecting with it on the west. The reference to the monument at the center of Hoyt and Water Sts., are: —

Northeast, 47.9 to fence post.

Southeast, 62.8 to brick chimney.

The location of these monuments should also be shown on plats in the office, which should denote the distance between the monuments and the angles made by the intersecting streets.

With these preliminary remarks, I will proceed to the consideration of —

STREET IMPROVEMENTS.

It has been said that "water is the greatest enemy which a roadway has to contend with," and experience has fully demonstrated that fact.

From the construction of the most primitive kind of road, to that of the most improved modern pavement, that fact should be kept in view, and the cardinal principle to be applied to them all is DRAINAGE, both surface and sub-drainage.

Whatever the particular quality of improvement to be made to a street, the first duty of the engineer is to see that proper provisions are made for drainage.

Some soils, as those of a gravelly nature, provide in themselves for perfect sub-drainage, but those of a retentive nature, such as clay, should be thoroughly underdrained by means of tile drains; if sewers have been constructed in the streets to be improved, good outlets for the drains can be had in them; but if not, some other method must be resorted to.

The matter of grades for the gutters of paved streets is another important point to be considered. Sufficient grade should be given them to carry rapidly the surface water to the nearest sewer basin, or other outlet provided for taking care of such water. Generally speaking, the minimum grade should be 4 inches per 100 feet, but this will depend somewhat upon the character of the improvement. A gutter paved with large, smooth flag-stones, requires less grade than one paved with cobble stone, or some other material offering greater resistance to the flow of water. The proper form of cross-section should also be considered. As in the case of grade of gutter, so with the cross-section, the greater resistance offered by the surface of the pavement to the flow of the water, the greater the crown that should be given to the roadway.

Taking, for example, a street to be paved with cedar blocks, as probably that class of improvement is the one most generally adopted in the cities of Michigan, the minimum grade, then, for the gutters, should be 4 inches per 100 feet, and the crown for a 30-foot roadway, 7 inches.

The following sketch (Fig. 2) shows a half section of a 30-foot cedar-block pavement.

Plans and Profiles for an improvement should give all needed information. The title should indicate clearly what it is intended to represent. The plan should show width of improvement, location of tile drains, sewers, man-holes, basins, culverts, and all other fixtures. Profiles should show grade of finished surface, grade of tile drains, profile of surface of ground on center line, and the profile of side lines might also be placed thereon to indicate the difference between the grade at any particular point and the surface of the adjoining property; and further, the scale should be shown, as it is sometimes inconvenient to pick up a plan from which the scale as well as the measurements, etc., have been omitted. A small table placed in one corner of the plan, containing the estimated quantities of the material to be used in the improvement, is also of use to those examining the plans, and saves the engineer an endless amount of trouble in answering questions.

Make the plans of a uniform width, as they can then be more conveniently filed in a case prepared for them. A width of 14 inches will be found convenient; this will give plenty of room for plan, profile, title, and other information. The plan and profile being made to a uniform scale of 40 feet horizontal to 4 vertical, by cutting to this width, 42-inch paper can be used without waste.

Indicate upon the plans all changes and additions, if any, made during construction, at the time they are made, as "delays are dangerous," and the alterations are apt to be forgotten after the lapse of a few weeks.

Properly label and index all plans, so that convenient reference may be had to them.

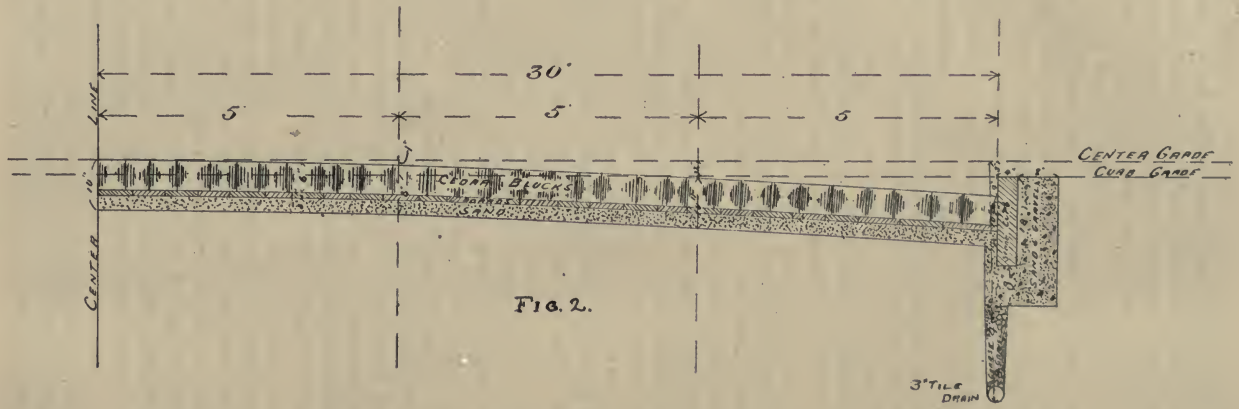

FIG. 2.

Half Section of 30ft Cedar Block Pavement

The Specifications should be carefully drawn; and, as much as possible, cover every point that is liable to arise during the construction of the work, so that the bill of extras may be reduced to the minimum.

They should be full enough to cover every contingency which can be forseen, and yet should be brief, concise, and to the point. A verbosity of language should be guarded against, as it leads to confusion, and makes the meaning less plain than would a shorter, clearer style. Describe plainly the method of construction, the kind and quality of the material to be used, and the method of measuring the work.

The specifications, in fact, should indicate in good, plain English just what is intended to be done, and nothing else.

Construction. — It behooves the engineer to see that proper and constant supervision is given to the work during its construction, as upon it depends largely the faithfulness with which the work is executed. For this purpose, a person properly qualified to judge of the merits of the material and workmanship, should be kept constantly upon the work, and he should receive his instructions from, and report direct to, the engineer in charge.

In many municipalities, the power of appointing such an inspector lies with the Board of Aldermen, who usually make their appointments solely upon political grounds, and without reference to the qualifications of the persons to fill the positions to which they are appointed. This, of course, is wrong, and to the detriment of the corporation doing so. The power of appointing or discharging inspectors for public works should rest entirely with the engineer. In fact, after the contract has been let, the engineer should be given entire and unrestricted charge, and he alone should be held responsible for its faithful execution, and for the acts of his subordinates.

Care and Maintenance of Streets. — In the case of earth streets, the road-bed should be kept well rounded up, and all ruts filled in so as to prevent the water from standing upon and saturating it. In some places the habit prevails of depositing rubbish, old cans, chips, and the rakings from the back yard, upon the streets. This should be prohibited by proper regulations. Ashes, especially coal ashes, are not detrimental to a road, but rather an improvement, as a road-bed formed of this material presents a hard surface, and is less liable to form ruts during wet weather. The side ditches should be constructed to a true and uniform grade, and kept free from rubbish, that the surface water may rapidly pass to the outlet provided for it.

It is frequently difficult in a flat, level country, with a clay subsoil, to prevent water from standing and stagnating in the street ditches. In such cases, tile drains placed two to three feet below the bottom of the ditches will overcome that difficulty, the bulk of the water passing over the surface to the outlet provided; the remain-

der, which usually remains to stagnate and pollute the healthfulness of the city, will find its way into the drains, thus leaving the ditch in a clean, sightly condition.

The benefits to be derived from tile drainage cannot be overestimated. The system not only greatly increases the healthfulness of the city by lowering the water line in the soil, but it drains and permits an earlier use of the road-bed in the spring of the year, by carrying off the water caused by rain storms and melting snow and ice, instead of permitting it to remain and accumulate. In constructing tile drains, care should be taken to provide good outlets, as upon this depend largely their efficiency.

The cost of these drains is not great, ordinarily three-inch tile is sufficient, where it is unnecessary to go far for an outlet. The tile can be laid at from 60 cents to $1.00 per rod; the manufacturer's list price is $17.00 per 1,000 feet. Usually, a discount from the price list, of 10 per cent and better can be secured, for the tile delivered on the line of the work. Three-inch tile, therefore, purchased at 10 per cent off list price, and laid for 75 cents per rod, will cost, complete, about $1.00 per rod, and a corporation cannot invest its money to better advantage than by the construction of tile drains.

Paved Streets should be kept clean and free from dirt. The frequency with which the streets should be cleaned, will be determined by the uses to which they are put. Cleaning may be done by days' labor or contract; either by hand, with brooms and shovels, or, in dry weather, with a street sweeper drawn by one or two horses, men and carts following behind the sweeper to take up and cart away the sweepings.

The impression a stranger receives upon his first visit to a city, depends very materially upon the appearance of its streets. A dirty street is not only unsightly, but unhealthy, as the accumulation of dust and dirt becomes saturated with the urine of horses, and other offensive matter, which is given off in noxious vapors during warm weather.

Ruts, holes, and depressions in a paved street, should be repaired as soon as discovered. The old adage of "a stitch in time" applies here with much force. A small hole or depression, left to take care of itself, will rapidly increase in size, until what could have been repaired for a few cents at first, will cost many times that amount to replace in good condition.

Sewers. — Having had a general plan prepared, it only remains, as any particular sewer is ordered to be constructed, to prepare detailed plans and specifications for the work.

The remarks made relative to plans, profiles, and specifications for street improvements, will apply with equal force here. The plans should show, not only the location of the sewer, but all manholes, basins, connections, etc., and upon the completion of the sewer, all connections and branches should be located with refer

ence to some permanent object. A convenient way is to show upon the plan the distance between each branch or connection and a man-hole. Branches for private connections should be placed in the sewer every 25 or 30 feet apart. Construct catch basins where required, usually at each street corner, as the basins will then take the drainage from the gutters of both streets; but the location of the basins will depend somewhat upon the established street grades. The basins should be constructed of sufficient size to catch and retain the bulk of the dirt and rubbish washed in from the street. The basins used in East Saginaw are constructed of 8-inch brick walls, 3½ feet in diameter in the clear, and 8 feet in hight, with the outlet into the sewer, 4 feet above the bottom. The basins should be cleaned each year, after the spring rains, or oftener, if required.

In their construction, too much care cannot be taken to lay the sewer to a true and uniform grade; the joints of pipe sewers should be well cemented, and the inside of each length of pipe cleaned as soon as it is laid, otherwise obstructions will be formed by the cement which may be flushed through the joints, around which accumulations of sewage will form, and cause stoppages in the sewer.

For the inner ring of the invert of brick sewers, the hardest and smoothest bricks should be selected, and each joint neatly struck, so that as little resistance as possible may be offered to the free flow of the sewage.

All brick for sewers should be inspected, and the soft bricks, and bricks containing lime, rejected. In warm weather, the brick should be thoroughly saturated with water before being used. This will prevent the absorption by the brick, of the moisture from the mortar, and will also readily detect the presence of lime.

The mortar box should also be closely watched, especially if the contractor furnishes the cement. The best plan is for the city to furnish the cement, as it is then certain of securing a more uniform article, and there is no inducement for the contractor to mix poor mortar; but entire reliance should not be placed in the manufacturer. The cement should be tested before being used in the work. Short-time tests may be made which will indicate in a measure the value of the cement. Tests should be made for fineness and tensile strength. The report of the committee of the American Society of Civil Engineers, "on a uniform system for tests of cement," presented at the annual meeting of that society in 1885, and which may be found on page 388, Vol. 14, of the *Engineering News*, contains a fund of useful information for making these tests. Gillmore's "Limes, Hydraulic Cements, and Mortar," is also a valuable work on this subject.

In mixing the mortar, the proper proportion of cement and sand (usually 2 of sand to 1 of cement, when natural American hydraulic cement is used) should be placed in the mortar box, and the two thoroughly incorporated before the water is added, other-

wise the mortar will not be of uniform quality, some portions being richer in cement than others.

The mortar should be used in the work as it is mixed, thus securing the first set of the cement in the masonry.

If an inspector is necessary on street improvements, it is much more important to have one on sewer work, as sewers are buried beneath the surface of the earth, and defects in material and workmanship not detected before they are covered, are liable to remain undiscovered until some portion of the sewer fails, when a large expense is entailed in making repairs.

For an inspector of brick sewers, an intelligent, competent mason should be employed, as he understands "the tricks of the trade" better than one who has had no special training in that line, and can more readily detect bad workmanship.

In connecting lateral sewers with the mains, the laterals should be constructed on such a curve that the flow from the lateral will be discharged in the direction of the flow in the main, otherwise an eddy will be formed in the main sewer, which will invariably cause a deposit, and consequently an obstruction.

Construct man-holes at all changes in the alignment of the sewer, and as much oftener as may be found necessary for proper inspection and care. In the case of pipe sewers (12-inch and over), man-holes from 150 to 200 feet apart will usually be found sufficient; while for brick sewers, it will not be found necessary to place them as close together as for pipe sewers.

Care and Maintenance.—Sewers should be kept as clean and free from deposits as possible. For this purpose, occasional flushings should be resorted to, or flush tanks, located at the head of the lateral sewers, and discharging at regular intervals.

The outlets, if discharging into running or other water, should be placed sufficiently above the normal level of the water to insure their free and unrestricted discharge. When a sewer starts below or partly below the surface, the capacity of the sewer is decreased by the area occupied by the backwater from the lake or river, and the sewage coming from above, and discharged into this slack backwater, is there deposited, and so much of the sewer occupied by this backwater then becomes an elongated cess-pool, and an active factor for the manufacture of sewer gas.

The growth of willow trees should not be permitted in the vicinity of sewers, public or private. Experience has demonstrated that the two cannot live harmoniously together. The roots from the trees, if unrestricted, will enter, and in a short time completely fill, the sewer. To illustrate: In the summer of 1885, a 12-inch pipe sewer was constructed in one of the streets of East Saginaw. The pipe was laid at a depth of about 11 feet, in a stiff yellow clay soil; on one side of the street grew three medium-sized willow trees. During the past season this sewer was removed, to make room for a large main sewer; and, upon taking

out the pipe of the old sewer, it was found that the roots from these trees had entered the pipe, and a mass of roots, somewhat resembling a piece of cocoanut matting, 75 feet in length, 2 inches thick, and 15 to 18 inches wide, was removed from the sewer.

Many other instances of a like nature have come under the observation of the writer. In some cases, the sewers have been completely filled with the roots, necessitating the removal of the sewer, and the destruction of the trees.

In conclusion, it may be well to offer a few general —

REMARKS.

The quality of the improvements to be made in the streets of a young city, will depend very much upon its natural resources, and the first improvements will be made with a view of reducing the first cost to the minimum. The city with age and population, will demand something better, more durable, and of necessity more costly, than that first adopted; and in time will probably go through the whole category of roads, from a cheap gravel or planked road to that of one of block stone or asphaltum.

Michigan having such an abundance of timber suitable for pavements, naturally that material is used very extensively for the improvement of the streets of its cities. Cedar seems to be the timber now most generally adopted for the better class of wooden pavements, but owing to its lack of durability (which is also true of any wood pavement), it is really one of the most costly which can be constructed.

Many of the eastern cities, notably Washington, D. C., have practically abandoned the use of wood, and are adopting other materials.

Washington, which previous to 1879 had over thirty-four miles of wooden block pavements, costing over $4,000,000, has quite abandoned its use; and has now almost entirely replaced the old pavements with stone or asphaltum.

Sanitarists protest strongly against the use of wood for paving, as being injurious to health, and with very good reason; wood being of such an absorbent nature, readily retains the liquid filth from the street, to be given off, during warm weather, in odors offensive both to the senses and to health.

But the fact is apparent that, so long as wooden pavements can be constructed so much more cheaply than those of a more durable and less objectionable kind, just so long will wood be used, yet in the construction of the pavements and the selection of the material, care should be taken to make them as durable as possible.

Cedar, as most generally used, is stripped of its bark, cut into suitable lengths, and placed upon the foundation prepared to receive it, retaining all the sap wood, the portion quickest to decay, and the portion which most readily absorbs the filth of the street. Remove the sap, and you remove the most objectionable part of the wood.

Experience has shown that the life of a pavement, constructed of *sapless* cedar blocks, is longer, and that the surface wears smoother and more uniform, than when the sap is left on; for the sap wood being first to decay, hastens the destruction of the rest of the block. Then again: the blows from the wheels of passing vehicles wear away the sap more rapidly than any other part of the block, thus forming depressions in which to hold the water and wash of the street, to be absorbed by the blocks, and giving to the whole a rough, uneven surface over which to ride.

It was the intention of the writer to dwell somewhat upon matters pertaining to sewerage and other municipal works; but this paper has already exceeded the limits originally assigned to it. One word more, however, to the engineers here assembled.

Remember, our calling is not only of an executive nature, but it is more exalted than that. If we do not administer directly to the moral welfare of our fellow-men, we should at least contribute to their physical well-being. We can do this by example as well as by precept. Convince him of the unsanitary conditions of his surroundings, and indicate the remedy; show him wherein the pollution of his supply of water for domestic uses lies, and how it leads to physical debility and death. By continuous and untiring efforts in the right direction, much can be done to improve the condition of those who live in our respective communities.

A man has never attained to his most exalted position until he ceases to be selfish, and works for the improvement and elevation of others.

JOHN J. GRANVILLE.

Prof. Carpenter. — "I found at Memphis that their sewer system has not a good reputation at home. They have flush tanks at the heads of the small laterals. They use the Fields flush tank, which is a simple affair, consisting of a siphon arranged at the side of the vessel, the water going out with a rush. They report it as somewhat uncertain in its action. The siphon does not always act, so that the water, instead of going out with a rush, goes out at the same rate that it comes in. The city engineer reports that the use of a tilting trap, and an inside lip which reduces the size of the siphon, will cause it to act."

Mr. Appleton. — "Is there a deadener to this trap? They used the tilting traps in London years ago, and the noise of them was a great nuisance."

Prof. Carpenter. — "It is not needed, being below the street."

Mr. Appleton. — "There is a trap in this city having a movable bottom, which I put in several years ago, that has worked well, and never failed. It is not automatic, nor intended to act as an intermittent flushing trap. We do not put in a brick basin, because cement pipe is cheaper, and just as good. It is one thing that a cement pipe is good for."

Prof. Carpenter. — "Has Mr. Granville had any experience in the use of brick for pavement?"

Mr. Granville.— "I have not. I have received reports from Ohio engineers in regard to it, and samples of the brick used. It was not a vitrified brick. The trouble with brick pavements seems to be in the proper selection of the brick, to get them of a uniform quality. Some engineers retain a percentage until the pavement has been tested by one winter's frost."

Mr. Appleton — "If ground slate is mixed with clay, it makes it perfectly durable, but the trouble is in a false economy which will not pay for the best."

Col. Muenscher. — "Some cities require a good deal of blue clay in the brick."

Mr. Appleton. — "There must be a good deal of sand in a good brick, but it must also contain other material."

Prof. Carpenter. – "I saw a good many samples of brick at the brick-makers' convention. I think we have no clay in Michigan suitable for such brick. They must be very hard, dense, and not vitrified. A vitrified brick is not so strong as one which is not. In Cleveland, brick is as cheap as wood, and it can be laid down in Detroit as cheap. They have good brick in Ohio."

Mr. Watkins. — "In a sanitary point of view, is not the vitrified brick the best, being less absorbent?"

Prof. Carpenter. — "I do not know as there is any difference."

President Steele. — "I think we had better drop this part of the discussion here. We shall have the topic up later, in the paper from Prof. Greene. Have we anything in regard to other kinds of pavement, say of wood? In Traverse City, the streets are underlaid with sand. I don't know how deep. We have a pavement there which is a compromise between a stone pavement and a gravel road. The gravel packs very hard, and is very successful. We have plenty of cedar right at hand."

A. L. Reed. — "What sort of foundation is best for a block pavement?"

Mr. Granville. — "It is best to put boards under blocks. The first block pavement we had in East Saginaw was put down without boards, and the blocks went down unevenly. We roll the streets with a ten-ton roller, put on three inches of sand, and then cover with inch boards."

Pres. Steele. — "At Grand Rapids, they have cedar blocks on a gravel bed well rammed down, and covered with nothing but gravel well rammed. They have excellent drainage That may have a decided effect on the durability of the pavement, and speaking of that, if you want a durable plank, take one that has been in the mortar bed."

Col. Muenscher. — "This system was introduced into Grand Rapids sixteen years ago, when I was city engineer, and I believe it is the best there is. You must have a good foundation. Excavate a foot in depth, and fill it with gravel, not sand. The blocks in this foundation have stood ten years without displace-

ment. Leave the boards out when you have a clay bottom. The water runs through, and will rot the boards first. Then, too, the boards are always being cut and taken up, to make connections with gas, water, and sewer pipes, and can never be put back in good condition."

Mr. Granville. — "Right here is a point for criticism. In making sewer, gas, and water connections, the earth is softened. If boards are not put in, the blocks will go down. The boards will to a certain extent prevent that. If the blocks are well filled between with fine gravel tamped in, you have almost hermetically sealed the pavement, so that no water will go through. In East Saginaw we try to reduce the evils of taking up the pavement, by requiring people to make their connections the fall of the year preceding the paving of the street. If they wish to do it after the street has been paved, they are charged $25, to pay for the permanent damage to the pavement. We thus do not have much disturbance of the pavement. We take up a 16-foot section at a time, and never allow a board to be cut."

FREIGHT YARDS AND SIDINGS.

In looking over the reports of former meetings of this Society, I find several able and exhaustive articles on the location and construction of railways. There is, however, among others, one item which has been pretty much overlooked; that is, sidings and freight yards. They are not much thought of in the location of railways, and railway companies usually think that after a road is located and the main track laid, they can dispense with the services of most of their engineers; so the work is left to the trackmen, and the engineers are off to new construction. Consequently many of them have no experience in track work, and if by chance they are called upon to do such work, they are likely to commit blunders. This is one reason trackmen often have a contempt for engineer's stakes.

The locating engineer ought to have in mind the places where side tracks are likely to be put in, and then make the grades at such places as nearly level as possible. Serious accidents accompanied by loss of life have occurred from cars being started by the wind, and running out on the main track. This can be prevented by the stop-blocks in use on some roads, provided there is no neglect to put the blocks in place.

There should be as few switches as possible in the main track. Let the yard be developed from the side tracks.

There ought to be at least some attempt at uniformity in the laying out of the freight yards of any particular road. If there is a regularly organized engineer department, and the road master's

department is, as it always ought to be, subservient to the engineer department, there will be no difficulty in securing uniformity of plan.

Of course, yards will vary in the number and length of tracks, to suit local needs. This uniformity will conduce largely to economy and ease in handling traffic. If there is a plan determined upon before the yard is begun, the discovery will not be made that the freight house is located where there ought to be tracks, and that there are tracks where the wagon road ought to be.

There ought to be no open culverts or cattle-guards in the vicinity of freight yards or sidings.

Railway companies should care for the comfort and safety of their employees, even if they are not liable for damages.

The yards should be well lighted and well drained. Yard work is disagreeable and dangerous enough without wading ankle deep in mud or slush.

The blocks which are bolted in the throats of frogs, in the mouths of switches, and in the ends of guard rails, are useful in preventing men from catching their feet, and being thrown down and run over.

Some roads use a switch like the "Wharton" in the main line, and the split switch in the yard. Others use the common stub switch all around. Whichever is decided upon, let all the yards be similar, and brakemen will sooner learn the road, and in case of a strike, new men will the quicker become available. In staking out a siding or yard track, let not the engineer be too fussy. Now-a-days frogs are numbered according to the ratio of width to length, as 1 in 6, 1 in 10, commonly called No. 6 or No. 10. Methods are given in the various engineer's pocket-books for computing the distance from mouth of switch to point of frog. Suppose the engineer has found the distance to the end of the frog to be 58.97 feet. Let him stake it out 58 or 60 feet, for no track-man will cut a rail to humor his odd hundredths.

The remark is applicable which I once heard an eminent engineer make in reference to transit work. He said, "It requires a good deal of ability to know when to slight transit work." So I say it requires some judgment to know when to comform strictly to theoretical measurements.

In staking out a freight yard, the tracks are indicated by stakes on the center line with a tack in each. In large yards, to prevent confusion, the stakes may be painted a different color for each track.

The mouth of switch is indicated by a stake marked "M. S.," and the point of frog, by a stake marked "P. F."

The turnout curve may begin either at the mouth of the switch, or the heel. In the latter case, one end of the switch rails is spiked fast, and the curvature obtained by the movement of the switch rails. This makes the switch turn harder. It also changes

the "lead," or distance from mouth of switch to point of frog. In case it is required to turn out from a curve either inside or outside, the pocket-books give intricate formulas, but the following method, due to the late Charles H. Fisher, Chief Engineer of the New York Central, will answer as well:—

It has been shown that for practical purposes, the lead is nearly enough the same on straight lines as on curves. Now suppose that we wish to turn out from the inside of a 4° curve with a switch angle of 1° 20′, and a frog angle of 7° 10′. The lead, as may be found from the tables, or by computation, is about 58 feet. A 4° curve turns 2° 19′ in 58 feet. Adding the frog angle, 7° 10′, we have a total angle of 9° 29′. To meet this, we have the switch angle 1° 20′, and the curvature of the turnout. Subtracting the switch angle, leaves 8° 9′ to be turned by the turnout curve in 58 feet. This gives about a 14° curve.

In these days, when railways find it necessary to practice every economy, let not the freight yards be overlooked. It is just as easy and just as cheap, if the matter be taken in hand in time, to have a good, safe yard, as to have a poor, dangerous one.

O. C. Gillette.

Pres. Steele. — "I am glad to hear this paper from Mr. Gillette, and that he has given us in it a practical rule to work by."

Col. Muenscher. — "Very serious accidents sometimes occur from cars being blown from the side track to the main track. A simple and effectual preventative is to make the side track six inches lower than the main track. No wind can then blow a car from the side to the main track."

EVIDENCE OF FLOWAGE.

Mr. President and Gentlemen: —

The surveyor is left to his own resources to a great extent in determining questions of flowage, and I shall not attempt to treat the subject here, as I am not the right man to do it, and shall be content simply to bring up the subject for discussion. To this end, I will give, briefly, the circumstances of a recent case.

By rights given under title of a deed, a dam was constructed entirely across the Kalamazoo River. The hight to which the right would raise the water, was definitely fixed by permanent bench marks on stone and tree. For a long term of years, this condition of affairs remained *in statu quo*. At last the requirements of civilization and more factories called for about two more feet of water, and with flash-boards that amount was easily obtained, often raising the water thirty inches above the prescribed right. The proof of these facts was permanent, clear, and undisputed. The

point denied was that although the water was raised unduly, it had no effect on fifty acres of land lying half a mile and more up the river.

The natural width of water was ten or fifteen rods. Above the dam, the water now spreads out to a width of twenty rods. The complaint of overflowed land commenced half a mile above the dam, and at this half-mile point, the water is six inches higher than at the bench mark, which is about eight rods above the dam.

An unmeasured line of levels was run from the bench mark along the river to the land, making there a bench mark at the same level as the old bench mark. The line was then extended and measured along the river and the land about 28 chains, and at suitable and convenient intervals, as many stations were made and lettered as was thought necessary. In this case, only six were made for fifty acres, as the land was not very uneven. From these six stations, cross lines were run due south; the river runs west, and levels were taken every eight rods. All these cross lines, that were needed to reckon the acres of wet land, were measured. The rest were paced, and with a few bench marks at H. I., this completed the survey.

Profiles and a map were made with contour lines of the land, showing, by small circles, the exact position of all the stations; in red ink, the hight of each station above the ice, and in green ink, the hight above the water of the river, when the water should be at its proper level, in this case, the hight of the dam, the dam being correct. Now comes in the question, What is a proper level at the land, under the circumstances? Is it the level of the dam? or should six inches be added to that level? or should still more be added? In other words, how much will water pile up under these conditions, and how much under other and dissimilar conditions?

A very important and separate set of river notes was kept, just as important to the purpose of survey, as the survey itself. The main purpose of the survey is to show the connection (if any) between the overflowed and wet condition of the land, and the raising of the dam with flash-boards. These notes show the exact position of the surface of the water, very early in the morning, of each morning, at the dam, and at the land, before the mills are started; also the surface at night, of each night, at the dam and at the land. The first morning a thin ice stuck to everything along the river, and remained two days. The water drew down three inches, at noon of the first day, at the dam, and two and one-fourth inches at the land. But the wind blew strong that day from the west, and up the river, and raised the water three-fourths of an inch at the land, because the water went down eighteen inches the next day at the land and dam alike. The second morning a heavy coat of ice formed one inch thick and about two inches lower than the first morning, two inches lower

at the dam and two inches lower at the land. At the latter place, ice formed entirely across the river, but not above there. Thermometer, 22°. At night of the second day, the water had gone down eighteen inches at the land, and just eighteen at the dam. The wind was now reversed.

Of course it is the peculiar province of the court and jury to say that these facts mean nothing, and show no relation between the dam and land, and the judge generally takes the trouble to point out to the jury that the Supreme Court of the State has decided that a surveyor's evidence is not the evidence of an expert, and that they need not give it any more weight than the evidence of anybody else. Nevertheless, these facts should all be noted fully, and written out with care, mapped, and submitted.

Ice does not always form just when you want it to, nor at all times of the year. But stakes can be driven at the dam and at the land, and water marks be made by pressing in tacks at the surface, at the times of high and low water, and as extended a record kept as possible and as the time will allow. Indeed, the date and hour can be written on the stake itself, and against each tack. Better still, at the land notches may be cut on saplings growing in the water. These notches may be referred to, in months and years to come, with confidence, when it shall be necessary to take more evidence, or to verify what has already been done, knowing that they cannot be driven down or raised by ice.

These water-sprouts and saplings present a new and important branch of evidence of their own; namely, that they never began life one or two feet under water, or even six inches. Hence the map can show a few places where sprouts are growing in the water, and show its hight above their union with the stump. This measure must be taken, in all cases, at the top of that union, as the growth is mostly on the lower side. There can also be marked upon the map the position of a few stumps standing in the water (if there are such), giving the size and kind of timber.

Another equally conclusive source of evidence of the facts required by the survey, may be given under the following conditions: When there are even a *few* spots of sand or fine cultivated loam along the edges of the high-water line, this line will be nicely marked, sometimes in one way, sometimes in another. Close and accurate marking will be found where a light dash of rain or snow or hail has printed all the exposed surface, while the sand, covered with water, will be smooth; and when the mill owners see the surveying party preparing for business, they are sure to draw off the water as fast as possible. At least such is always the talk, and the facts seem to sustain it. Then the surveyor can read, as he walks, the exact position of the high-water line, and as the water recedes, compare its positions, above and below. This printed line is far better than the water line itself, as the latter is continually changing, and is likely to

introduce an element of error, while the printed line will not move until covered with water, and will then stop again at some particular grade. E. STRONG.

Prof. Carpenter. — "There is one question raised in that paper that has been discussed a great deal before this Society, as to what constitutes the hight of a dam. Probably all the surveyors of Lansing have made extensive surveys to determine that question with reference to the dam at North Lansing. The Court refused to answer the question as to what constitutes the true hight of a dam, and decided the case entirely on the ground that the dam had been raised from its original hight, and must come down again, without regard to the actual hight of the dam. We do not know yet whether the head of water is to be measured from water below the dam to water above, or from the ground below the dam to the top of the dam, or in what way the true hight should be determined."

Mr. Hodgman. — "The point made in this paper, as I understand it, is in relation to fixed bench marks on the bank of the stream."

Mr. Appleton. — "Is it not rather how much the standing wave is? We know that this wave varies in different conditions."

Mr. Hodgman. — "The question raised, it seems to me, is. If we raise a dam a certain distance, will it raise the water in the stream above level with the dam, or will it raise it higher than the dam, and if higher, how much at different points in the stream above, and how will this affect the flowage?"

Mr. Appleton. — "It will do that. In the case here, the water was raised enough above the dam to be readily determined."

Mr. Watkins. — "Did you determine the hight with reference to certain fixed marks?"

Mr. Strong. — "Yes, sir."

Mr. Watkins. — "The point was once raised in this Society whether a stump is reliable for a bench mark, and it was decided that stumps cannot be depended on."

Mr. Strong. — "That might be true, but I think it has been sufficiently well determined that a tree will not vary in its hight, but each part retain its original level. This has been demonstrated by a large number of experiments. The bench marks in this case were made upon trees and boulders, and stakes were also driven into the water in some places to a certain depth below the surface, so that even if some of the bench marks were moved or destroyed, we would still have something left."

Prof. Carpenter. — "In the case of the North Lansing dam, I made the survey when the water was very high, and Mr. Appleton, when the water was very low. The standing wave from the dam, as I measured it, was reduced as you neared the head of the dam. I think when Mr. Appleton had two inches of high water, I had nearly two feet."

Mr. Appleton. — "The standing wave varies with varying conditions of the water, but I think we pretty well settled it."

Mr. Strong. — "Did you take into account the wind?"

Prof. Carpenter. — "This river is thoroughly protected from the wind."

Mr. Appleton. — "About four miles of it is through the woods."

Mr. Watkins. — "I know a dam is a dam with me."

President. — "I don't find it so. A farmer who thought he was terribly injured by a dam in Leelanaw County, commenced suit to take away a dam below him. The gentleman who owned the grist-mill that was situated on the stream, had to suspend operations, and went to a good deal of expense and trouble to find out the actual fall. The farmer claimed that the dam had raised the water in the lake, and had caused it to overflow the adjoining lands which he owned in that vicinity, and he was making every effort to abate the nuisance. It was tried in the Justice Court, and next in the Circuit Court for the county of Leelanaw, and I was called upon to take some observations and levels about there on the part of the owners of the mill. I found the hight of the standing wave very much to the astonishment of the opposing counsel, who could not see how water could be anything but level, or how a dam could actually raise the water above it, although, as I told them, it could be easily detected with the levels. But the point which secured the defendant's case was that happily there were four government meandering posts on that lake, and they were witnessed, and those witnesses were all perfect, and when I went there with a boat, I found everything all right, and that the original stakes which the government surveyors put in the swamp were perfect, although they were thirty or forty years old then, and they were exactly where they ought to be in every case. They found that the survey which I had made showed the water in the lake at the same hight as it was shown to be by the government surveyor, or a little lower, hence how could the dam have caused the rise of the water? The fact was that the rise in the stream had been caused by a large number of springs on the farm owned by the complainant, so that he really was the party to blame for the overflow, and not the defendant's dam. The point won the case. Of course, the leveling is very nice, and it was something they could not get around."

TESTS OF MICHIGAN WOODS.

THE last two winters I have had considerable opportunity to become acquainted with the methods of testing, first at Cornell University, and since at the College. The machine we have is arranged to take material up to a certain size, two and a half inches square or less, and the testing capacity is 50,000 pounds. The power is applied by means of a hydraulic press. This machine is arranged, as most of them are, so that we can test lengthwise, either in tension or in compression, and crosswise or transversely. Now, in testing material, we want to get the breaking weight and the elastic limit. There will be a certain stretch, up to which point it will go back to its original form, or nearly so. This is the elastic limit. Just where this elastic limit is, is really more important to know and to find out in our investigation, than how much it will take to break it. It is necessary, then, in order to determine that, to have some instruments by which we can measure the stretch of it, or how much compression it will stand in pushing it together. I have for this purpose arranged two little points which I place on two collars, between which I put a micrometer of the Brown & Sharpe pattern, and in this way I can measure the elongation. Now so long as this elongation is uniform, we are within our elastic limit; and so long as it keeps within the elastic limit, it will go back, or nearly back, to its original form. But a time comes presently when the stretch becomes greater, and instead of being one-thousandth of an inch, it increases to from two to sixty thousandths of an inch, and more. You will notice in the specimens that I have here that some of them look as though they had been tapered off, when actually they were just the same size before testing.

Here is a piece of tool steel about one-fifth of a square inch in area, which took actually 33,000 pounds to pull apart, being the strongest piece of steel I have ever tested. Here are some specimens of a bronze which is considered to contain about 5 per cent of aluminum, and here is a piece of common bronze. If you will look at this specimen, you will see the effect of the pulling. You will notice that this is drawn out of shape. Sometimes the piece breaks in a very queer way, and in pulling it out the tension causes it to open up in several places. Now, in testing woods, this much we have found out — and probably it is a well-known fact to all that are using woods — we can never get a fair tensile test of wood, on account of its being almost sure to give you a splitting break, rather than a square cross break. Woods are not fit materials to be used in places where tension is required.

For compression and transverse strains, wood works very well, and the results we get with our testing machine are very satisfactory. I have tested forty or fifty different kinds of wood. Hard

maple runs up the highest in transverse strain, having reached 18,924 pounds to the square inch. Among some other specimens I have tested, is white pine, which ran as high as 8,000 pounds, some specimens running a little below and some above. In some other reports I have the locust, as running highest, 17,000 to 19,000 pounds.

Wood is generally used in a frame or truss, either as a beam, or as a post or pillar. In the first case the effect of the load is to bend the beam, and finally to break it, where most bent, or close to the points of supports. The power of the beam to carry such a load, we term its transverse strength, limiting the term usually to the bending only, and using the term transverse shear when we refer to the strain next to the points of support.

Where wood is used as a pillar, the effect of the load is to compress or shorten it; if the pillar is less than about ten diameters long, the effect is generally to crush it, either by a wedge flying out from one or more sides, or by the doubling up of the fibers of the post. When the pillar is long with respect to its diameter, the effect of the load is to bend it, often into a complicated form. The theory of this last case is not a simple one, although within the elastic limit it seems to agree well with experiment.

Wood is sometimes used as a tie rod, in which case the strain tends to pull the fibers apart, or to lengthen the rod. Wood is poorly adapted for such strains, since the effect of cross-grain or knots or any defect whatever would be more seriously felt here than in the other cases. A large and uncertain excess of strength would in this case be needed.

Wood is sometimes used as a mere bearing block, in which case the effect is the same as a very short pillar.

The theory of action of forces on materials is treated at length in various works on the strength of materials, and can be studied exhaustively in such books. For the convenience of those who may desire to look the subject up thoroughly, I will mention a few works published by Wiley, as follows: Burr, "Strength and Resistance of Materials;" Lanza, "Applied Mechanics;" Church. "Mechanics of Materials;" Merriman, "Mechanics of Materials;" Wood, "Strength of Materials;" Thurston, "Materials of Engineering." The work by Burr is especially full of information.

For the convenience of those who may not have access to any of the works mentioned, I give a few formulas for the simplest cases. These formulas, probably, strictly speaking, will apply only when the load is within the elastic limit, but the results are in most cases nearly correct up to the breaking point. It is customary to figure the formula as correct up to the breaking point, and then take loads one-fourth or one-fifth the amounts given, as safe loads. By the elastic limit is meant that load which produces the first permanent deformation in the shape; it varies all the way from one-fourth to nine-tenths the breaking load, in different materials. In

testing the strength of materials, it is important to locate the elastic limit; the method of doing this is as follows: equal increments of load are added, and the resulting change of form is measured. So long as equal increments of load produce uniform deformation, the elastic limit has not been passed. When the deformation increases at a greater rate for the same increase of load, it is assumed that the elastic limit has been passed. This involves a very minute and accurate measurement, as the deformation in all cases is small, and a small error may make a considerable difference in the result. The approximation location of the critical point is the best that can be done.

Many experimenters do not believe in the existence of an elastic limit, but the discussion of that point does not come within the limits of my paper. The coefficient of elasticity is obtained by dividing the load per unit of area by the stretch per unit of length, at any point within the elastic limit. It is greater for the stiffer materials.

The following formulas represent the simple cases of breaking:—

For Tension:

$P = FS$

P = breaking load.
F = coefficient for Tension.
S = area square inches of cross section.

For Crushing:

$P = CS$

C = coefficient for crushing.
S = area square inches of cross section.

For Compression — Long rectangular columns square ends of wood:

$$P = \frac{F' S}{1 + \frac{1}{250}\frac{h^2}{l^2}}$$

F' = coefficient for compression long columns.
S = area in square inches.
l = length in inches.
h = least dimension in inches.

For Transverse — Beam supported both ends, load at center, Rectangular beam:

$$P = \frac{2}{3}\frac{b h^2}{l} T$$

h = depth in inches.
b = breadth in "
l = length " "
T = coefficient for transverse breaking.
P = breaking load.

For Shear:

$P = F' S$ in which F' equals the coefficient for shearing.

In all the above formulas:

P = breaking load.
S = area of cross section.
l = the length in inches.

The following results are in common use:—

TABLE OF COEFFICIENTS OF STRENGTH OF WOOD — FROM CHURCH'S MECHANICS OF MATERIALS.

	Elasticity.	Strength at Elastic Limit.	Strength at Breaking Point.
Tension	200000 to 2000000	3000 to 19000	6000 to 28000
Compression	.....	.....	.....
Short Blocks	350000 to 2000000	.....	2000 to 10000
Compression	.....	.....	.....
Long Pillars	.....	.....	7200 .....
Transverse	1000000 to 3000000	1000 to ?....	4000 to 20000
Shear { across grain	.....	.....	1500 to 8000
Shear { with "			500 to 1200

The tensile strength of woods is difficult to obtain experimentally, because of the liability of breakage by splitting instead of pulling the grain fairly apart. Any imperfection is especially manifest in this kind of strain.

I have made but few tests to ascertain the tensile strength of wood, and these gave results considerably less than the values tabulated in our works on strength of materials. As showing the method of making these tests, I submit the log of one test complete: —

TEST OF SEASONED HARD MAPLE 8.67 INCHES LONG, SQUARE CROSS SECTION 7-INCH AREA.

Load Shown by Testing Machine.	Micrometer Reading inches.	Stretch in inches.	Load per square inch.	Coefficient Elasticity.	Remarks.
0	0.486	0			
1000	0.488	0.0025	1428		
2000	0.490	0.0025	2857		
3000	0.494	0.0035	4285		
4000	0.498	0.0040	5999		
5000	0.503	0.0050	7143	3.753320	Near the Elastic Limit.
5500	0.511	0.0080	7857		
6000	0.5140	0.0030	8571		
6500	Rupture.		9285		Split and sq. break exposing 6 sq. inches.

The following are some values found for other woods : —

TESTS OF WOOD IN TENSION — SUMMARY OF RESULTS.

Kind of Wood.	Approximate Elastic Limit.	Breaking Strength.	Coefficient Elasticity.	Length inches.	Area sq. inches.	Remarks.
White Pine.....	2685	6712.3	671220	13.2	0.739	Round poor break.
Swamp Oak... ..	3846	7692	1797663	7.0	0.526	
Black Walnut....	2978	6400	1240000	6.0	0.503	
Hard Maple.....	5999	9285	3753320	8.67	0.700	

LOG OF TRANSVERSE TEST OF SUGAR MAPLE.

Load applied at center 24 inches long, 2.9 inches deep, .86 inches thick.

Load Applied.	Reading of Micrometer inches	Total deflection at center inches.	Coefficient of Strain per square inch.	Coefficient of Elasticity.	Deflection per 100 lbs. inches.	Remarks.
0	0.921					Well seasoned specimen Rectangular cross section.
500	0.844	.077	2490		.017	
800	0.811	.110	3984	1199000	.011	
1000	0.781	.140	4980		.015	
1200	0.760	.161	5976		.0095	
1400	0.734	.187	6972		.013	
1600	.698	.223	7968		.018	
1800	.683	.238	8964	1246000	.0075	
2000	.659	.262	9960		.012	
2200	.624	.297	10856		.0175	
2400	.597	.324	11952		.0235	
2600	.558	.363	12948		.0195	
2800	.525	.396	13944		.0165	
3000	.480	.441	14940		.0225	
3200	.427	.494	15936		.0265	
3400	.367	.554	16932		.030	
3600	.284	.637	17928		.0415	
3710	Broke.			18924		

It is to be noticed that the deflection, although somewhat irregular, remains about constant, until the load is greater than

2,000 pounds, in which case the coefficient is 9,960 pounds per square inch.

I found accidentally that a very complete determination of the transverse strength, and various other properties of woods, had been made for the tenth census reports of the United States. These determinations were made for Prof Seargent by Stephen P. Sharples, of Cambridge, Mass.

In the results as published, all dimensions and results are expressed in French measures. The specimens for transverse strength are uniformly of a square cross section, each side being 4 centimeters. In breaking, the specimens were vertical and the force applied horizontally. For crushing, the blocks were uniformly 32 centimeters high and 4 centimeters square.

The specimens were all thoroughly air dried, and the weight in pounds per cubic foot is given.

The fuel value was obtained by actual combustion with an analysis of the resultant products; the results are expressed with an arbitrary series of numbers, the fuel value being in proportion to the numbers.

The number of specimens of each kind varied from five to fifteen.

Thinking these results might be useful if put in an available form, I reduced the average result of each species to English measures, and have arranged in the following table the properties given for all the native specimens known to grow in our own State. These results are so full and complete as to make it entirely needless to publish the meager results of my own tests. I give, however, the log of one test for transverse strength, to show the method of testing, rather than to give information as to the results.

PROF. R. C. CARPENTER.

Mr. Watkins. — "How do you find swamp oak, as compared with other woods?"

Prof. Carpenter. — "Swamp oak is not as strong as hard maple. It runs, I believe, about 14,000 to 15,000 pounds per square inch."

Mr. Watkins. — "Among mill men I believe it is considered the stiffest timber for shafting."

FROM CENSUS REPORTS — REDUCED TO ENGLISH MEASURES.

Woods of Michigan.		Weight per cubic foot, pounds.	Approximate fuel value.	Coefficients of			
Botanical Name.	Common Name.			Elasticity.	Ultimate Transverse.	Longitudinal Crushing. Pounds per square inch, 8 diameters high.	Resistance to indentation. $\frac{1}{10}$ in. depth per sq. inch.
Liriodendron Tulipifera	White Wood — Tulip Tree	26.36	63.26	1283000	6797	5520	1120
Asimina Triloba	Paw Paw	24 74	39.61	663000	5560	3615	900
Tilia Americana	Basswood Linden	28.20	45.00	1183000	8374	4875	890
Xanthoxylum (Colden) Americanum	Prickley Ash	35.23	50.15	1035000	9115	6175	1130
Acer Saccharinum	Sugar Maple — Rock Maple	43.08	68.75	2064000	16225	8670	3400
Acer Nigrum	Black Sugar Maple	43.09	68.66	1043000	13679	7470	3500
Acer Dasycarpum	Silver or White Maple	32.84	52.52	1560000	14590	6650	1540
Acer Rubrum	Red or Soft Maple	38.50	61.65	1335000	11634	6400	1360
Niguudium Aceroides	Box Elder — Ash-leaved Maple	26.97	47.95	800000	7522	4370	1480
Rhus Copallina	Dwarf Sumach	32.86	52.42	1030000	9427	5200	1465
Rhus Venenata	Poison Sumach	27.31	77.28	1485000	9314	7960	2800
Cercis Canadensis	Redbush — Judas Tree	39.65	63.18	985000	10689	6460	2460
Gymnocladus Canadensis	Kentucky Coffee Tree	43.21	68.88	1485000	10977	5520	2170
Gleditschia Triacanthus	Honey Locust	42.00	66.86	1535000	13124	6950	2240
" Monosperma	Common Locust	45.76	72.89	1670000	17087	8150	3790
Prunus Americana	Wild Plum	44.96	72.02	1173000	9460	8200	2900
" Serotina	Wild Cherry	36.28	58.14	119400	11160	7560	2750
Pyrus Coronaria	Wild Crab Apple	43.92	70.11	893000	6630	5775	3400
Amelanchier Canadensis	June or Service Berry	48.85	77.95	1695000	16000	9430	3860
Cornus Florida	Flowering Dogwood	53.81	80.98	1153000	12790	7360	4250
Nyssa Multiflora	Pepperidge — Black or Sour Gum	39.59	63.66	1150000	11630	6470	2640
Fraxinius Americana	White Ash	40.77	65.16	1422000	10520	6460	2260
" Pubescens	Red or Downy Ash	38.96	62.35	1134000	9840	6050	2770
" Quadrangulata	Blue Ash	46.78	74.50	1090000	9120	6870	2750
" Sambucifolia	Black Ash	39.37	62.72	1090000	11300	5770	2630
Sassafras Officinale	Sassafras	31.42	50.38	709000	5510	5250	1770

Ulmus Fulva	Slippery Elm	43.35	69.77	1340000	13160	7520	1950
" Americana	American or White Elm	40.54	64.54	1070000	11200	6220	2530
" Racemosa	Rock or Cork Elm	45.26	72.20	1550000	15520	8250	2760
Celtis Occidentalis	Hackberry — Nettle Tree	45.41	72.08	970000	9150	5780	3650
Platanus Occidentalis	Buttonwood – Sycamore	35.38	56.52	1225000	8770	6230	2240
Juglans Cinerea	Butternut	25.46	40.66	1450000	8230	5450	1240
" Nigra	Black Walnut	38.11	60.91	1545000	9750	8000	2640
Carya Alba	Shagbark Hickory	52.17	83.11	1980000	16970	9820	3680
" Sulcata	Western Shagbark Hickory	50.53	80.35	1462000	13600	7770	3910
" Porcina	Pignut Hickory	51.21	81.36	1423000	14320	8100	4140
" Amara	Bitternut	47.06	74.74	645000	13170	7200	3320
Ostrya Virginica	Ironwood	51.62	82.42	1936000	17780	7530	3100
Carpinus Caroliniaria	Blue Beech	45.41	72.26	1631000	14200	6880	2900
Quercus Alba	White Oak	46.35	74.39	1373000	10330	7070	2880
" Macrocarpa	Burr Oak	46.45	74.06	1310000	8990	6800	3150
" Bicolor	Swamp White Oak	47.75	76.18	1273000	9570	6800	2970
" Prinoides	Yellow Chestnut Oak	53.63	86.09	1590000	18380	8020	3600
" Nigra	Black Jack Oak	45.64	72.39	1370000	14900	6880	3940
" Rubra	Red Oak	40.75	65.28	1608000	11940	7100	2380
Castena Vulgaris	Chestnut	28.07	44.95	119500	8053	5240	1420
Fagus Ferruginea	Beech	42.89	68.48	1716000	17460	6540	2630
Betula Lenta	Black Birch — Sweet Birch	47.47	75.97	2200000	17160	8670	3070
" Luta	Yellow Birch	40.84	65.34	2280000	17600	8670	2170
" Papyracea	Paper or Canoe Birch	37.11	59.40	1800000	14950	6750	1700
Populus Tremuloides	Aspen or Poplar	25.13	40.10	1145000	9430	4560	1040
" Monilifera	Cottonwood	24.24	38.53	1405000	10830	4680	1060
" Balsamifera	Balsam Poplar	22.65	36.11	1200000	7630	4440	1000
	Balm of Gilead	25.93	41.42	1033000	8230	3760	860
Thuja Occidentalis	Arbor Vitæ — White Cedar	19.72	31.53	727000	8730	4110	770
Juniperus Virginiana	Red Cedar	30.70	49.11	945000	10360	5860	1940
Pinus Strobus	White Pine	24.02	38.47	1195000	9220	5560	970
" Resinosa	Norway Pine	30.25	48.41	1595000	11320	6370	1100
" Banksiana	Jack Pine	29.67	47.50	1325000	9100	5470	1340
Picea Nigra	Black Spruce	28.57	45.71	1555000	11450	5660	1020
" Alba	White Spruce	25.25	40.38	1440000	11465	4720	960
Tsuga Canadensis	Hemlock	26.42	42.20	1280000	10900	5240	1100
Abies Balsamea	Balsam Fir	23.80	38.02	1150000	7000	5030	1000
Larix Americana	Tamarack	38.86	62.16	1790000	9450	7600	1400

BRICK STREET PAVEMENTS.*

As towns grow into cities, and their street traffic increases, pavements become a necessity.

In parts of Illinois, where timber is scarce, and stone and gravel almost wanting, hard-burnt bricks have been used for paving, and the cheapness of the material has commended its use to the people.

In Bloomington, Ill., fifteen years ago, a courtway was paved with bricks as an experiment, and this courtway, exceptional for a first experiment, is still in a fair condition, after scarcely any repairs.

Bricks fit for paving are so different from common bricks, that we have thought some facts about the former might be interesting.

Clay which will make good paving bricks should be able, without fusing, to withstand a sufficient degree of heat, and for a long enough time to render the bricks hard and impervious to water. Yet, while the value of a clay for paving brick depends largely upon its refractory nature, fluxing agents, in proportions yet undetermined, are necessary to render the bricks homogeneous and tenacious.

Fire clays are generally hydrated silicates of alumina. Potash, soda, lime, magnesia, iron, and other elements are sometimes present in small quantities, and render the clay less refractory the greater the quantity of them present. When 6 to 10 per cent is found, the clay will generally melt. When the clay is siliceous, 3 to 4 per cent makes it fusible. When it is aluminous, 6 to 7 per cent of oxide of iron does not render it non-refractory, because aluminites are mostly of a refractory nature.

Lime alone is completely infusible; but in very small quantities in clay, it makes a brick fusible at high temperatures. It is especially to be avoided in clays for paving-bricks, because the heat of burning reduces the carbonate to caustic lime, which in the pavements will absorb moisture and cause disintegration of the brick.

Magnesia in small quantities is said by Egleston to make clay fusible.

The alkalies, from 1 to 3 per cent, make clay fusible.

The change of color in burning is due to iron, or to a small percentage of bituminous material. Iron, beyond 6 to 10 per cent, if the clay is siliceous, usually renders it fusible.

Silica and alumina constitute the refractory parts, and the impurities the fluxing part.

Silica is infusible alone, except at the highest temperatures of the oxyhydrogen blow-pipe. It possesses no binding property,

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*Condensed from a thesis by Mr. Edgar Ryan, University of Michigan.

and a clay having an excess of it is rough, and lacking in plasticity and tenacity, thus rendering the bricks weak.

Alumina is highly refractory and is binding. When combined with iron or other bases alone, it makes infusible aluminites; but with silica present, it fuses more or less readily.

The plasticity of clay is due to the fineness of the particles, to the presence of alumina, and to the water of combination, which may be driven off at a red heat, the clay losing its power of combining with water.

The refractory nature of a clay is then due to the presence of alumina and silica in excess, and to the absence of potash, soda, lime, magnesia, and iron.

The characteristics of all fine clays may be said to be, that they do not effervesce with acids; that they make a paste with water, which paste can be drawn out without breaking, and is very plastic; that when dry they are solid, and break into scales when struck; have a soapy feeling, are easily scratched or polished, can be cut into long ribbons with a knife, and appear somewhat like horn.

The commercial test is the only sure way of ascertaining the value of a clay.

Some clays which we will mention have been used more or less successfully in making a paving material.

"MINGO" FIRE-CLAY, HAYDENVILLE, OHIO.

The clay from which the Hayden patent Paving Block (of which a sample is submitted) is made, has nearly the compactness and density of fine-grained sandstone, and yet is semi-plastic. It can be characterized neither as a hard nor as a plastic clay. Nitroglycerine is used in mining it; yet, while apparently very hard, it is readily reduced to powder in the dry pan under heavy rolls. The clay when ground is excellent for laying fire-bricks, mixing easily, working smoothly, and resisting great heat.

The paving block in burning is subjected for ten days to 2,000° F.

This paving block is square in plan, $5\frac{3}{4}$ inches on a side, and $4\frac{3}{4}$ inches deep, hollow below to facilitate burning and save material, and having a flat upper surface broken by indentations intended to provide a firmer foothold for horses. These indentations, however, seem to be of little permanent value, as under heavy traffic they are soon obliterated. The blocks are salt-glazed. The outer top edges are slightly beveled, to admit readily a filling of sand, pitch, or other material in the joints after laying. One thousand blocks will lay 26 sq. yds., at 50 cts. per hundred, or $1.92 per sq. yd. The sidewalks are $1\frac{1}{8}$ inches thick and top 2 inches. The endurance of the block is therefore limited to the wear of the top. A block weighs about $9\frac{1}{2}$ lbs., giving about 360 lbs. to the sq. yd.

An analysis of this clay, by Prof. E. M. Reed, is subjoined, and a comparison is made with the well-known Stourbridge clay of England.

	Mingo Fire Clay, Haydensville, Ohio.	Stourbridge Fire Clay.
Silica	72.24 per cent.	73.82 per cent.
Alumina	16.87 "	15.88 "
Iron	0.16 "	2.95 "
Lime	0.50 "	trace
Magnesia	trace	trace
Alkali	1.09 "	0.90 "
Water	5.44 "	6.45 "
Total	100.00 "	100.00 "

PAVING BRICK CLAY, VIRDEN, ILL.

This clay is found in a bed 25 feet thick, lying just beneath a stratum of slate, and 275 feet below the surface of the ground. It is compact, with a distinct cylindrical cleavage, of a light steel-gray color, and emits, when first mined, a characteristic odor resembling that of slate. Although it is blasted out, it has only the hardness of soft slate, and can be reduced to an extremely fine powder free from grit. It has a specific gravity of 2.5595. A piece kept at a white heat in a hard coal fire for twelve hours, was not disintegrated, and concentrated nitric acid failed to produce effervescence.

It is reduced to powder by being first passed through a Blake crusher, then finished in a dry pan crusher. The process is imperfect, as particles of uncrushed clay weighing as much as fifty milligrams have been taken from a green brick. These particles had not apparently been affected by the water used for tempering, and they remain intact through the process of burning, being easily discerned in a burned brick, and rendering it heterogeneous. When tempered with water, the clay becomes plastic, tenacious, and firm, being readily formed into different shapes. A sample is here submitted.

CLAYS FROM BLOOMINGTON, ILL.

These may properly be called "surface clays," and are of three varieties.

"A" is a yellow, aluminous clay, very fine and plastic, found three feet below the surface, in a bed 12 feet in thickness. It is subjected to no process of grinding or reduction, being simply tempered in a vertical pug-mill directly from the bank. It burns to a grayish-red color.

"B" is a hard-pan clay just beneath the "A" layer, and from one to one and one-half feet thick. Great difficulty is experienced in reducing this clay to an impalpable powder. When dug and exposed for one winter, to "weather," or disintegrate, very good results are claimed for it. But when this clay is reduced at once, uncrushed particles occur which cause unequal shrinkage in the

burned brick, leaving small cavities where, in the pavement, water may accumulate and cause disintegration by freezing. Hard-pan clay generally burns from pink to cream in color.

"C" is a blue clay directly beneath the hard-pan clay, and has a depth of from one to six feet. It is plastic or semi-plastic, fine, firm, and very tenacious, and usually burns to a chalk white. In many respects it is similar to the light blue fire clay used for fire and paving brick at Empire, Ohio.

From the experience of the best manufacturers of paving brick, we are led to conclude that fineness of grain in clay is most essential, and where that property is found in a plastic clay, provided the clay is sufficiently refractory, care only is needed in tempering and burning, to produce good results. When fine-grained clay has a compact and hard structure, no pains should be spared to reduce it, in a dry state, to an impalpable powder.

Where the clay is neither dry nor fine, but of desired composition, it may be calcined and then finely ground. This may appear a trivial matter, yet, if two samples of the same clay are ground, the one finely and the other coarsely, the latter will require much more heat before vitrifying to a homogeneous mass; while the more finely it is ground, the stronger and harder the bricks will become, the better they will stand abrasion, and the less liable will they be to break.

THE MANUFACTURE OF BRICKS.

The great diversity in the clays makes the process of manufacture a difficult problem, for the experience gained in one place may be of little or no use in another.

In several towns, notably Ottawa and Virden, Ill., manufacturers use the plant commonly employed for making tile, modified for bricks. At Virden, Ill., where the capacity is 1,600 per hour, the process is in substance as follows: —

The clay hoisted from the mine, is delivered from tram-carts to a Blake crusher, and then finished in a dry-pan crusher. It is then delivered to a tempering machine, and forced from the latter by a screw through the desired mold, whence it issues in one continuous bar, 8½ inches by 4¼ inches in a section. It runs over a series of rollers, and is cut up by wires spaced two inches apart, in a hinged frame worked by hand. The bricks are removed on tram-cars to a dry-house or shed, and left until sufficiently dry. They are then placed in down-draft cylindrical kilns, having hemispherical tops, and burned from 70 to 90 hours with bituminous coal, on grates, at intervals, around the outside base. An 80 horse-power engine suffices for this plant. The heat is sufficient to melt tin, and to cause pieces of copper to run together.

"A" and "B," of dimensions 8⅛ in. by 4¼ in. by 2 in., are burned in the same kiln, but differ in color and quality. "A" is dark, almost black, rings more and appears stronger than "B,"

which is a light red. They are quoted at $8.00 per thousand free on board cars. "C" is a brick from the same clay, and made in the same way, but intended for a finished brick for face work on buildings.

At Bloomington, Ill., the "A" clay is simply tempered in a vertical pug-mill, molded into bricks by hand, dried in a yard, racked in rectangular stacks, and burned for from 96 to 120 hours with wood and bituminous coal placed in the usual arches. It is a grayish red in color, 7 in. by 3½ in. by 2¼ in., quoted at $8.50 per thousand at the yards, or furnished in sufficient numbers to lay *two* courses, one flat and the other on edge, for $1.12½ per sq. yard. Bloomington "B" and "C," quoted at the same figures, have about the same dimensions. All have a sharp, clear ring when struck.

Bricks are made at Ottawa, Ill., from fire-clay which is mined, and from common surface clay. They are burned some 50 hours with bituminous coal, in kilns similar to those used at Virden. When burned, the interior is dark gray in color, very hard, and cannot be cut with ordinary tools. They are of two dimensions, 4 in. by 5 in. by 12 in., and quoted at $1.00 per sq. yard, which is about $35 per thousand, and 4 in. by 4 in. by 12 in., at 75 cts. per sq. yard, or about $28 per thousand.

At Empire, Ohio, a light blue fire-clay is taken from a drift in the side of a mountain, ground in a pan, molded by hand, and burned in up-draft open-top kilns, with natural gas. The bricks are hard, ring like steel, and are quoted at $10 per thousand. Much the same process is employed at New Brighton, Pa., where the bricks made from fire-clay are claimed to be as hard as granite, to emit a sharp, steely ring when struck, and to resist all effects except natural wear.

In all the above cases, no addition of sand or other material is made. In Wheeling, W. Va., a brick, in form a truncated pyramid, is made from clay and iron slag.

As the condition and life of a pavement depend upon uniformity of the bricks, they should all be burnt to a uniform hardness, which cannot be obtained in ordinary kilns. If soft and salmon bricks are found at the top of the kiln, while those next the arches are over-burned, warped, and melted, the cost of the rest, suitable for use, is much enhanced by the waste.

CRUSHING STRENGTH.

All specimens were crushed by the direct application of weights. The specimens were all ¾ in. by ¾ in. by 1½ in., placed on end between pieces of soft pine about ¼ in. in thickness. The length chosen for the samples permits the shearing action to have its full effect. All were ground to true size on emery wheel and grindstone, and carefully calipered.

In Virden "A," the short axes were parallel to the 8½ in. and 4¼ in. dimensions of the brick from which it was taken. It was compact, having no holes or spongy places, took on sharp corners and smooth surfaces, was excessively hard, and would glaze at a white heat on the emery wheel. With 5,266 lbs., it crushed by a scale of about ⅛ in. by ½ in. by 1 in., first flying off from one vertical edge, accompanied by a sharp report, immediately followed by splitting into nearly prismatic fragments, parallel to the action of the force.

A second specimen from the same brick, with short axes parallel to the 4¼ in. and 2 in. dimensions of brick, crushed at 5,625 lbs.

Virden "B" did not take on as true dimensions as "A," though free from holes. Crushed at 5,160 lbs.

Virden "C," like the preceding, crushed at 4,985 lbs.

It was difficult to bring Bloomington "A," as well as the next specimen, to the required dimensions, because of a tendency to scale, when heated under the action of the emery wheel. Several holes occurred in them, as may be seen in the bricks. They also glazed somewhat under the emery wheel. Crushed at 5,693 lbs.

The second specimen crushed in smaller prismatic pieces, at 7,268 lbs.

Bloomington "B" was excessively hard to reduce to size, would also glaze, but not scale off, took on smooth surfaces and sharp edges, and had spots which contained a yellow powder. Crushed at 5,565 lbs.

Bloomington "C" was much like the above. Crushed at 5,280 lbs.

In the following table are given the specific gravity (mean of 5 determinations), the absorption for three, five, and ten days, after the specimens had been heated to a red heat, cooled in a desiccator and weighed, and finally the crushing strength per square inch of section.

Name.	Specific Gravity.	Per Cent Absorption.			Crushing Strength, lbs. on sq. inch.
		3 days.	5 days.	10 days.	
Bloomington "A"...	2.1852	3.79	3.92	4.06	12,920 max. 11,520 mean. 10,120 min.
" "B"...	2.3045	3.18	3.19	3.37	9,893
" "C"...	2.2269	1.87	2.20	2.70	9,386
Virden "A".....	2.3166	3.10	3.12	3.82	10,000 max. 9,680 mean. 9,361 min.
" "B"	2.4150	7.67	7.96	8.71	9,173
" "C"	2.3601	7.11	7.48	8.70	8,862
Hayden Paving Block..	2.2861	3.25	3.38	3.64	....

It may not be amiss to compare the crushing strength of the above with that of some common or building bricks.

Good Haverstraw stock bricks of a fair average, tested at East River bridge, by Mr. Abbot, with no packing between brick and machine, gave—

		Crushing strength.
Whole brick on end	max.,	3,060 lbs. on sq. in.
	min.,	1,600 " "
	average,	2,065 " "
Half brick on flat side	max.,	4,153 " "
	min.,	2,669 " "
	average,	3,371 " "
alf brick on small side	max.,	6,400 " "
	min.,	2,900 " "
	average,	4,612 " "

Experiments by Prof. W. A. Pike, Minneapolis, Minn., on building bricks. Half bricks between pieces of pasteboard.

		Failed with:
St. Louis, Mo., brick	flatwise,	6,417 lbs. on sq. in.
	edgewise,	4,080 " "
Hastings red brick	hard,	2,017 " "
	medium,	2,012 " "
	soft,	1,748 " "

BRICK PAVEMENTS.

Paving bricks are sometimes laid on a foundation of broken stone covered with cement mortar, and sometimes on sand. It will hardly be expedient to go into details now.

At St. Louis, ten years ago, strips of pavement 22 inches wide were laid down as a test, and a two wheeled cart with tires 2½ inches wide, and loaded to two tons, or 800 lbs. per inch of width, was rolled back and forth by machinery. The heaviest traffic at that time in St. Louis was 75 tons per day per foot of width, and the average for business streets was 35 tons. Estimating the effect of horses' shoes at one-third of this amount, 50 tons per foot were taken as a standard. The samples were weighed before and after testing, and were subjected to an amount of travel by the above cart equivalent to eight and one-half years on the street.

The total abrasion of the fire-brick pavement was 9 per cent., or a depth of ¾ inches, but about one-half of the bricks were broken. Asphaltum blocks under the same test wore 14 per cent., and but one was broken. Granite blocks were scarcely worn appreciably, while limestone had lost 10 per cent. The action of the elements would have affected the limestone still more, as would also probably have been the case with the bricks.

As a result, granite blocks were chosen for streets having heavy traffic. The tests seem to warrant the claim that brick pavements will answer well for moderate and light traffic.

Soft bricks intermixed may give trouble; but the first cold season will usually determine whether the bricks are hard enough,

as, if not, the moisture absorbed by them will freeze, and crumble the bricks by expansion.

At Nashville, Tenn., are used creosoted or bitumenized bricks, prepared by saturating common kiln bricks of medium hardness, under a high degree of heat, with liquid pitch, obtained by distilling coal-tar. These bricks have been laid about four years, on a good foundation of rolled macadam, bedded on edge in 1½ inches of sand, and rammed tight. They have been subjected to a considerable amount of traffic, and show very little if any wear. The cost was $1.80 per sq. yard for brick and laying on finished foundation.

At Youngstown, Ohio, fire-brick on cement concrete base and sand with pitch in joints, cost for all $1.73 per sq. yard. Their best bricks came from Empire, Ohio, and New Brighton, Pa.

At Allegheny City, Pa., fire-clay bricks from the West Virginia Fire Brick Company have been laid in two layers on rammed and rolled gravel and sand, at a cost of $1.95 per sq. yard, exclusive of grading. The pavement, in use three years, is stated to be very smooth, easily cleaned, and of a handsome appearance.

At Bloomington, Ill., some two and one-half miles of brick paved streets have been laid with bricks of home manufacture, "A," "B," and "C." The sample herewith was under traffic there twelve years. The corner and edge of one end, and also the large scale on the upper edge of the same side, were broken off with a pick in removing the specimen from the pavement. It does not appear to have lost appreciably in width, although the majority did not present so favorable an appearance, having generally lost the upper edges and corners. Such pavements, however, are not noticeably rough in driving over them, and afford good foothold for horses. The brick pavements in Bloomington, generally speaking, are in good condition, and are being constantly extended. They have stone blocks, Nicholson and macadam pavements also, and prefer brick, on the score of cost, durability, lack of noise, home production, ease of cleaning, and repairs. The entire pavement, two layers of brick, including *all materials*, grading, and stone curbs, cost $2.00 per sq. yard, with laborers at $1.60 per day, teams $3.25, and sand 80 cents to 90 cents per cubic yard, delivered.

Jacksonville, Ill., has laid over three miles of pavement with Virden brick. Some down for five years is now in good condition. One piece, of one-half mile, two layers, cost, including everything, engineer's services and all, $1.92 per sq. yard. Sand was filled into the joints in place of pitch.

Cincinnati had a pavement on rolled sand. A failure.

Peoria, Ill., paved two blocks in 1886, and five blocks in 1887, with Ottawa paving brick, and Chicago used the same brick three or four years ago on 63d St. car tracks.

The intersection of Washington and Dearborn Sts., Chicago, was paved with Hayden paving blocks in 1886. In March, 1888, it was found to have succumbed to the very heavy traffic, and crushed.

Galesburg, Decatur, Champaign, and Springfield, Ill., have laid more or less brick pavement within five years, the major part of which has given satisfaction.

New Orleans and Wheeling, W. Va., Steubenville, Ohio, Camden, N. J., and other places, have laid experimental sections.

The disadvantages of brick pavements arise from lack of uniformity in the material, and the liability of incorporating in the pavement brick of too soft and porous structure, which crumble the first winter under the action of frost.

When laid on a solid foundation, the advantages are, cheapness, smoothness, cleanliness, freedom from noise, and sanitary excellence as non-absorbent. See table above.

Taking all things into consideration, it is superior to macadam, wood, and, for a maximum traffic of three tons, superior to granite.

CHAS. E. GREENE.

President. — "Gentlemen, we must not let this paper lead us to think that we live in Ohio or Illinois. We live in Michigan. I have no criticism upon the paper as it is, but we would be glad to know: first, whether we have any Michigan clay good for this purpose; secondly, whether those clays, if we have any, have been fully experimented with, and if so, with what results? Can any gentleman give us any information in regard to that?"

Secretary. — "I think Mr. Appleton knows something about Michigan clay."

Mr. Appleton. — "It is another kind of brick we make. But I understand an experiment is now being made with slate dust, to see what the result will be, and to see if the brick produced will be well adapted to paving."

Mr. Foster. — "I know nothing of brick-making, but I wish merely to state that I made some observations in the Upper Peninsula a good many years ago, when I was engineer of the canal that passed through Lake George. We found in that lake for about 3,000 feet a mass of red clay, very refractory. There was an immense amount of it, to all appearances inexhaustible, enough to supply the entire State for ages."

Mr. Appleton. — "I have been investigating brick-making somewhat, and have found that there is a very good quality of brick made for this purpose in several different sections of the State."

Prof. Greene. — "I have also spent considerable time in looking up this matter, and I think the clay Mr. Appleton talks about does not make first-class brick, but even if it did, you can bring brick into the interior of the State of Michigan from Ohio or Illinois, at a much less cost than from within your own borders."

Mr. Appleton. — "I wish we could do away with this abominable wood pavement. North Lansing is paved with tamarack blocks. Most of our streets here were contracted at about 90 cts. per square yard, and the cobble stone with which we paved the gutters, at from 60 to 65 cents per square yard, and in some instances the cedar, has been put down for 80 cents per square yard, that including the whole business, sand and everything complete. Now this intersection of Capital and Michigan Avenues right here in front of the Capitol, as many of you well know, has been down but two or three years, while the paving on Washington Avenue has been down about eight years. That at North Lansing, where the tamarack was used, has been down about six years, and is now nearly worn out."

Prof. Greene. — "Then taking into consideration the life-time of the pavement, is not the brick pavement much cheaper?"

Mr. Appleton. — "Yes, sir, I certainly think it is."

Mr. Foster. — "When I was in the Upper Peninsula, I found several beds of fire clay only twenty-five feet from the surface, some of which I sent up to the iron furnaces, and it was pronounced first-class fire clay."

Mr. Mc Loughlin. — "I would like to inquire of Prof. Greene if he noticed any difference in the shrinkage of the raw brick and the burnt brick?"

Prof. Greene. — "You will see the shrinkage is not very much by examining these specimens. The shrinkage is very small indeed."

Mr. Appleton. — "The machine that makes this brick is of that style where there is just pressure enough to push the column of clay through the machine, and it is cut off by a wire into bricks of the proper dimensions."

Mr. Mc. Loughlin. — "I have made this subject of pavements considerable of a study, especially as we have decided in Detroit that it is necessary to substitute something for cedar blocks. I have given it about seven years of study, and there has been a great number of tests made to see if bricks could be made to stand the heavy traffic of our streets. Brick for pavement has not yet been made that is not porous, and that will not absorb considerable moisture. Mr. John Gladden has also given this question considerable study, and has spent considerable money, and even gone to the trouble of having special machinery made and an extra kiln built to burn these bricks, and paved the street from his own street to Louise St. with the brick he made. His pavement at the corner of Third and Louise Sts. has been down for about five years, and Louise St. has been paved with cedar blocks. The brick has stood fairly well there, but the traffic is light over that street. I find that in investigating this paving question, we have got to drop this idea of cheapness if we want good pavements, and if we expect to have good pavements, we must expect to put good material into

them, and the best of all is a good foundation. I think engineers will discard sand for a foundation. They will have to come down to cement, and then place stone, blocks, or whatever you wish, on top of that. I think for a cheap pavement, there is nothing like a wood pavement. If you would put under this kind of pavement, concrete instead of sand, I believe you would have a good pavement, but it would be quite expensive. At St. Louis they did some paving with locust blocks placed upon a bed of concrete, and it cost $3.65 per yard. In this method of paving, when your blocks wear out, you still have the bed left intact. You have always got a certain part of your work — the foundation — left upon which to re-pave your streets or make repairs thereafter. Therefore I think we should look at the foundation rather than what we put on top of it. But if you want a nice pavement and one that will last, you should put down a pavement of Trinidad asphalt. It is a question in my mind if it is not going to be the pavement of the future. There are objections to granite pavement in the way of noise. I witnessed in the cities of Brooklyn and New York a pavement that had been down for fifteen years. It was made of granite blocks of 3½ inches by 6 to 9 inches long and 7 inches deep; that pavement had been laid on broken stone which had been well rolled with a heavy roller, and then on top of that the paving stone which had also been rolled; but in that fifteen years of traffic over it, it had become very uneven, and at the time I was there they were then ending up the blocks, when it would be good for another fifteen years. It cost in the neighborhood of $4.50 per yard, or between $4.50 and $5.00.

"In Washington, where they have finely paved streets, and where they have had the Nicholson pavement, they have discarded it, and have adopted the standard pavement of asphalt. In Buffalo, Medina stone pavement has been preferred to other systems, and that put down there is now on its seventh year; Rochester has quite a large amount of it; St. Paul and several other cities which I might mention, have adopted this Trinidad asphalt pavement after a great deal of inquiry and investigation. The city of Detroit is now agitating this question, after having tested brick, wood, and various other kinds of pavement. We have a place on Michigan Avenue where we tried the brick pavement, but it was not found to give satisfaction. In the choice of pavements, you have got finally to get down to these two facts: You want solidity and elasticity, and these are the elements embraced in the Trinidad asphalt pavement. In the old world the people are still sticking to the stone pavements of one kind and another. Paris uses asphalt almost altogether, although right here I wish to state, what probably most of you know, that there are several grades of asphalt. The Neuchatel asphalt becomes very slippery with wear, but Trinidad asphalt does not. They are using fine sand, and mix with it as much

of the Trinidad asphalt as it will stand, but there is such a thing as taking too much sand In Columbus, this brick pavement is a failure. They pave with vitrified brick, and in slippery weather horses cannot stand on the pavement. They are now going to use asphalt instead. The brick of the best quality costs $1.92 per yard, and the cost of the foundation is still to be included. With the best brick you have, your pavement will cost $3.00 per yard, and I doubt very much whether that would be economy. The $1.65 brick would bring the cost up to $2.00 per yard. I would much rather have the road bed well filled with bank gravel, and well rolled, and then laid with 7-inch cedar blocks, well filled between with gravel. Then sprinkle the streets thoroughly, and they will last much longer than when not sprinkled, as the dry rot will not set in, and for the amount of money you will have a much better pavement than you would have with brick. If you will keep your streets well watered, the life of the pavement will be longer than when left subject to the weather. Any city that wants a *good* pavement should not put down any pavement excepting the asphalt."

Mr. Ames. — "The pavements of Grand Rapids are altogether cedar pavements. It perhaps might be advisable in some localities to use boards under the pavement for a foundation, but in Grand Rapids our soil is well drained, and it is not necessary. We have taken up and replaced pavement where all that we needed to do was to take up the blocks and put them down again, our soil being such that there is no danger of the blocks settling into it. While a city is growing, and the pavements are constantly being torn up for the purpose of putting down gas and water pipes, and putting in drains and sewers, it would hardly be advisable to put down any very expensive pavement; but it might be well for a city which has its growth to do it, along certain streets. Twelve years is the longest we have used pavement."

Mr. Mc Loughlin. — "I don't care what pavement is taken up, if you will hire competent workmen to do the work and not allow the ditcher to set back the blocks or stone, it can be put back in just as good shape as it was originally. But if you make your repairs properly, it will cost a good deal of money."

Mr. Granville. — "In Saginaw, toward the latter part of each summer the streets that are to be opened the ensuing year, are ordered, and upon such streets' being paved, the Board of Public Works, or its officers, order all connections to be made, though the city authorities have no means of compelling the putting in of anything but the sewer connections. They have the power after the pavement is once put down to compel the payment of $25 by the property owner who wishes to make any connection before entering the pavement, and then if they cut into the pavement over five feet, it is $1.00 for each additional foot. As a consequence, nearly all the connections are made before the paving is done. Now suppos-

ing at some future time a person wants to make connection, he makes his application, and agrees to pay all the damages of taking up and replacing the pavement; the street superintendent, or men under his control, make all the connections; the contractor or plumber makes the trench and puts in the pipes, when his work ceases, and the work of replacing the pavement is left in charge of the superintendent of streets; and the applicant pays into the city treasury the cost of the work."

Mr. Ames. — "In Grand Rapids, the city engineer has nothing to do with the streets. After the streets are opened, it is then in the hands of the Board, and the city engineer has nothing to do with it. The city has no ordinance compelling the people to make connections before the pavement is put down, and the result is that our streets are continually torn up."

Mr. Mc Leod — "At Manistee we adopted another system this year, differing somewhat from the one formerly adopted. At the time of putting in our sewers, we put in our lateral sewers. But we have nothing to do with regard to the water and gas pipes. I would like to ask the gentleman from Detroit, what kind of timber or lumber you use under the pavement?"

Mr. Mc Loughlin. — "That would depend a good deal upon the lay of the ground, and kind of soil; where you have a fair sub-soil of clay, a good board is sufficient; where you have boggy soil, a 2-inch plank."

Col. Muenscher. — "If you have a good natural foundation, I think the board foundation is entirely unnecessary. I agree with Mr. McLoughlin in regard to pavements, to a great extent. In the large cities it is all right to put down permanent foundations where the property is worth $500 to $600 per foot frontage, but in the smaller cities where it is worth but $50 to $60 per foot frontage, we have got to have something cheaper, as the paving would cost more than the property is worth. I am in hopes to see brick take the place of wood for pavements."

Mr. Mc Loughlin. — "We had occasion to take up some block pavement that had been down for some years, and we failed to find a rotten block in the whole, although it had been down so long that the blocks which were originally seven and a half inches high, had in many places become worn down to two and a half inches. They have in all Canadian cities a system of pavement with blocks, and their streets are sprinkled thoroughly every day, and any wood that is put down in that way is a good pavement, and much cheaper than brick. Chicago has adopted granite for its pavements, but the noise and the rumbling and roar of their wagons passing over them, make it very disagreeable, especially for residence streets."

Mr. Watkins. — "Here they all adopt a block that is seven or eight inches in length. Why not have a block only three or four inches, as it will be less liable to tip?"

Mr. Mc Loughlin. — "We find from experience that a seven-inch block is the best to use."

Mr. Watkins. — "In New York City, where I have seen all those various pavements go to the wall after a little while, the Rust pavement seems to be the best one for the larger cities. For small cities I think a short cedar block pavement is the best thing we can get."

Mr. Goodale. — "We have a small place of about 1,000 inhabitants, yet we need good streets, and we think we can afford good pavements. We have put down stone gutters with gravel and clay between. I would like to know what the comparative utility and cost of the stone pavement is as compared with cedar blocks."

Mr. Appleton. — "Cedar block pavement, with its excavation, costs from 80 to 90 cents per square yard."

Mr. Mc Loughlin. — "How large a block do you use?"

Mr. Appleton. — "We use anything from three to eight inches in diameter."

Mr. Watkins. — "Do you use boards for a foundation?"

Mr. Appleton. — "No, sir, we do n't need any here."

Prof. Greene. — "I know of some brick pavements in which the entire cost, including all necessary preparations and engineers' surveys, was only about $2.00 for a good pavement. I understand that the clay found in Southern Michigan is not good for brick for paving purposes."

Mr. Appleton. — "I want to ask the gentleman from Detroit, who just spoke, if he does not find it a rather difficult matter to get good *pavers?* You can find plenty of men who can lay the stone, but you cannot find very many men who can lay it properly. There are all sorts of schemes to get down a good deal of the pavement, but I always found it difficult to get just the right kind of pavers."

Mr. Mc Loughlin. — "There are lots of them; but if you want a good stone pavement, you do n't want to go to Detroit to get your good pavers. I can teach any sensible man in two or three hours' time, to lay a pavement, and lay it well. The stone should be laid dry, and rammed down with a rammer that will cover only one stone at a time. Of course it takes considerable time to teach a man so that he can lay to the crown of the street nicely. But no man can pave for me, and lay his 125 or 150 yards per day. If he lays 75 yards, he is doing a big day's work."

Mr. Watkins. — "How should stone pavements be laid?"

Mr. Mc Loughlin. — "The large end up."

Mr. Watkins. — "What is to prevent a person from kicking them right up?"

Mr. Mc Loughlin. — "They should be laid dry, as I said, and then rammed down well. The sand should then be broomed over them, and they should be rammed again, and the sand again

broomed over them, and again pounded down, and so on for three times. I have seen them put down where they could not be taken out with a pick."

NOTES ON BUILDING STONES.

MICHIGAN is surpassed by many other States as a producer of building material. Quarrying is not one of her most important industries. Recognizing these facts, the writer of the brief paper here presented, wishes to offer a few notes on building stones in general, and to call attention to the meagerness of the published information relating to Michigan stone, with the hope and expectation that, for some future meeting of this Society, a more extended and systematic paper may be prepared that shall show in fuller detail what kinds of stone are obtainable within the boundaries of the State, and to what extent it may reasonably be expected that the quarry industry can be developed. The writer wishes to say further that he has had but little opportunity personally to visit the quarries alluded to in what follows, and that he has relied principally for his information about them upon the following publications: (1.) The "Report of the United States Census for 1880;" (2.) The five volumes of "Mineral Resources of the United States," issued by the U. S. Geological Survey from 1882 to 1887; (3.) The reports of the Michigan Commissioner of Mineral Statistics for the years 1878–87; (4.) The several reports of the State Geological Survey. Outside of these publications, there seems to be little or nothing of value in accessible form that relates especially to Michigan quarries.

The United States Census of 1880 made record of such quarries only as did a business in the census year amounting to one thousand dollars or more. Of such quarries there were in the whole country, in 1880, 1,525, employing a capital of $25,414,497, and producing 115,380,133 cubic feet of stone, valued at $18,356,055. Michigan's share in these totals was nine quarries, with an invested capital of $74,700, and a production of 648,060 cubic feet, valued at $79,165.

The nine Michigan quarries of which statistics are given in the census volume, are the limestone quarries at Alpena, at Sibley's Station in Wayne County, and near Raisinville and Dundee in Monroe County, and the sandstone quarries at Lulu, Monroe County, at Stony Point, Jackson County, at Ionia, and at Marquette. No reference is made to the sandstone of L'Anse, though considerable work had been done at that locality as early as the year 1875, nor to the slate of Huron Bay. Besides the places just mentioned, the Michigan reports speak of several other localities where limestone or sandstone, that have either been proved to be,

or are supposed to be, of value for building purposes, have been worked to some extent, or are at least exposed to view in promising outcrops. Among these may be enumerated, though the list is doubtless incomplete, Springport, Sandstone, Parma, and Napoleon, in Jackson County; Flushing, in Genesee County; Trenton, in Monroe County; Bay Port, in Huron County; and numerous points of minor importance in Barry, Eaton, Hillsdale, Iosco, Kent, Saginaw, and Shiawassee counties.

In what has preceded, no allusion has been made to stone other than limestone, sandstone, and slate; and, indeed, there is no reason for expecting to find good building material of the crystalline or granitic character in the State of Michigan, except in the western portions of the Upper Peninsula, or among the boulders distributed through the glacial drift that almost entirely covers and conceals from view the sedimentary rocks of the whole lower Peninsula.

In regard to these rock-names and others in use, it may be well to say a word in passing before speaking more particularly of the quality and value of stone from individual quarries. Rock nomenclature is not in the most satisfactory condition. The popular names, *sandstone*, *limestone*, *slate* and *granite*, are made to cover almost every variety of stone in at all common use, except where occasionally some more specific term finds application; as, for example, *bluestone*, suggested by a characteristic color; or *flagstone*, named from the use to which the stone is to be put; or *Ionia stone*, so called from the locality where quarried. The term *slate* is a convenient one to apply to any rock that readily cleaves into thin plates with surfaces approximately parallel, and *sandstone* is a term generally applicable to rocks made up essentially of rounded grains of quartz, or other hard mineral held together by a cementing material of some kind or other, though it must not be supposed that all slates are alike, or that all sandstones have the same properties; but *limestone* includes not only the common, coarse varieties, but also the finer grained and more highly prized marbles and the so-called dolomites, or magnesian limestones. The name *granite* is perhaps the most abused of all. True granite is a mixture of quartz, feldspar, and mica, in which the different mineral ingredients are crystallized together, and are large enough to be recognized by the unassisted eye; but some rocks, locally known as granite, are nearly or quite barren of quartz, feldspar, or mica, and resemble true granite only in their crystalline granular texture. The traps, porphyries, greenstones, basalts, serpentines, etc., need no further mention at this time, for the reason that they occur in Michigan only in limited amount, or, at any rate, with only a very limited use for structural purposes. In the vicinity of Ishpeming, in the Upper Peninsula, marbles and serpentines do, indeed, occur, that take a good polish, and furnish pretty hand specimens, but, so far as known to the writer, they

are not obtainable in large, homogeneous blocks such as would be required for building purposes.

In determining whether any rock, by whatever name it may be known, is likely to prove serviceable as a building material, especial attention must be directed to its texture, that is, to the way the individual mineral ingredients of which it is composed are held together. In respect to texture, two great classes of rocks are recognized; viz., the crystalline and the fragmental. In the former, the mineral grains are held together by the mutual adhesion of crystalline surfaces, while in the latter, the rounded or the angular fragments, that once existed in other relations as parts of other rocks, are held or stuck together by the intervention of some foreign substance that acts as a mortar or cement. It hardly needs to be mentioned that the strength, durability, and value of a fragmental rock depend fully as much on the character of the cement, which may make up only a small portion of the total volume, as they do on the rock fragments that compose the mass of the rock. Crystalline rocks occur in greatest abundance in regions where eruptions of molten matter have taken place, or where sedimentary formations of great geological antiquity have been metamorphosed through the agency of moisture, pressure, and heat. It is for this reason that in Michigan the crystalline rocks are limited to the districts mentioned above, and that throughout the Lower Peninsula, where the geological formations underlying the drift range from the Upper Silurian to the Carboniferous, rocks of a fragmental, sedimentary character are the only ones to be expected, unless possibly a few of the limestones may exhibit to some extent a crystalline or subcrystalline character.

The well-known quarries of red, or reddish brown, sandstone at and near Marquette, are referred by geologists to the Potsdam period at the base of the Silurian system. The mottled appearance of some of this stone is due to the unequal oxidation of the iron that is present. The rocks of the other geological formations of the eastern portion of the Upper Peninsula appear to be too thinly bedded, too friable, or too much cut up by cracks and seams, for the production of blocks of desirable shape and size. The sandstones of the more southern counties of the Lower Peninsula are mostly subcarboniferous in age; the Ionia quarries are in the coal measures.

To be of value as a building material, a stone must possess sufficient strength, must be capable of resisting climatic and meteorological changes, must present a pleasing appearance, and must be obtainable in large quantity at low cost. These desirable properties are not dependent entirely, nor even to any large extent, on the mineral constituents of which ordinary rocks are essentially composed, for these minerals are all of the most common varieties; but rather on closeness and compactness of texture, on density and degree of consolidation, the character of the cementing material,

if any, and freedom from accessory ingredients, that, though small in quantity, frequently cause discoloration or disintegration and decay of the rock mass, in consequence of slow chemical changes that take place in them when exposed to the action of air and moisture.

So far as ability to resist crushing is concerned, it is safe to assert that in all ordinary structures, there is little or no danger of a rock's breaking or cracking under the load it has to carry, if only ordinary care is exercised in its selection. About fifteen years ago a report of experiments upon various American building stones was prepared by General Q. A. Gillmore, of the United States Army, and from this report it appears that of seventy-eight granites tested, the crushing strength in pounds to the square inch ranged from a minimum of 7,750 to a maximum of 22,750; for forty-seven limestones and marbles the minimum and maximum were 6,650 and 25,000; and for fifty-eight sandstones, 4,025 and 17,725. These figures do not agree exactly with those given by other experimenters, but they may be accepted as an approximation to the truth, and they certainly show that the stones in the lower courses of masonry are still abundantly able to sustain the weight of the superstructure in the highest building or column yet erected. There is still room for extensive study of questions relating to the causes of fractures along certain planes, and the development of weakness in certain directions under varying circumstances.

Among the several conditions that affect the durability of rocks, their porosity is one of the most important. Notwithstanding the apparent solidity and closeness of grain of the stones seen in daily use, it can be easily shown that many of them are porous in no slight degree. The pores and openings are indeed small, but their existence is made manifest in several ways, notably by the absorption of water. To show the extent to which different varieties of rock are capable of absorbing water, the following data are taken from Dr. T. Sterry Hunt's "Chemical and Geological Essays." The numbers represent the volumes of water absorbed in each case by one hundred volumes of rock. For fourteen kinds of sandstone experimented upon, the volumes of water absorbed ranged between 1.39 and 21.27; for five shales, between 0.75 and 7.94; for five limestones, between 0.30 and 1.70; and for twelve dolomites, between 2.15 and 13.55. In the most porous rock the absorption amounted to more than one-fifth its original volume.

Where any high degree of porosity exists, it is evident that this circumstance alone will facilitate the decay of a rock by introducing into its interior the agents of chemical change that are to be found in all atmospheric waters. What these chemical agents are, and how they act in association with mechanical and organic causes of destruction, would be an interesting subject for discussion, but such a discussion does not fall within the scope and purpose of the present paper.

PROF. W. H. PETTEE.

President. — "I feel rather humiliated that I should have to live in a State so long, that has in it no building stone fit for building purposes. I knew, of course, that when we wanted to build large buildings, like the State Capitol, we have to send outside of the State for building stone, but it seems to me we should have abundant material of that kind for smaller buildings."

Mr. Foster. — "We are not entirely destitute of good building stone in this State. At Portage Entry, near the light-house, there is a much larger quarry, and it is better equipped, than many in other States from whence we procure our stone. The stone is sent from there by means of scows to Marquette for building purposes, and they are using it to a considerable extent. The new Mining School at Marquette is being constructed out of it. It has the advantage of being located at a point that is very accessible, with a roadstead for a good harbor. Then on Isle Royal, I believe, on Siskowit Bay, there are cliffs, miles in extent, of stone that is of fine quality for flagging and paving stone, and this is also provided with a good harbor, being situated on the extreme south side of the island. No quarries have been worked there, although people from Chicago have looked at them, but have opened no quarries yet."

Mr. Watkins. — "What about Grindstone City stone?"

Mr. Pettee. — "That stone is used especially for grindstones, and I am not aware that it is quarried for building purposes."

Mr. Rothwell. — "I would also add that in the years from 1876–80 there were over 27,000 cubic yards of stone taken from Limestone City for use at the 'Soo?'"

President. — "Are there any other kinds of stone used in building at the 'Soo?'"

Mr. Ripley. — "Sandstone is used to a considerable extent, in fact, almost entirely for foundations to buildings, and there are one or two churches built with it."

Mr. Rothwell. — "There is some good building stone to be found in the quarries at Big Bay De Noquet and on the eastern side of Green Bay, although they have been worked but little."

Prof. Carpenter. — "There has been considerable of the Ionia and Grand Ledge stone used in this city for building purposes. It has been found to stand well. The Grand Ledge is of very poor color, but is found to be quite durable, and would be quite desirable stone for building purposes were it not for the dirty streaks running through it."

Mr. Ames. — "The stone procured from the sandstone quarries at Holland is of a light gray color, and when first quarried is quite soft, but grows harder upon being exposed to the air for a time. I have never noticed any discoloration from iron."

TIME AZIMUTHS.

It may not have occurred to many of our surveyors that in the recent establishment of Standard Time, we have a new means of finding meridian, — not new in a literal sense, for it is well known to navigators, — but new in that it has not been utilized by land surveyors.

We already avail ourselves of the properties of the "astronomical triangle," so called, for the purpose of finding meridian with the solar campass, or transit.

In this we determine the zenith angle of the triangle, and thence the supplement, mechanically, from the three sides, — a case of spherical Trigonometry.

But in the method I propose to bring to your notice, we have in the same triangle the two sides meeting at the pole, and their contained angle, which we may assume at pleasure, from which to find the zenith angle.

The two sides we have from the same source as when working with the solar transit.

The third element, — the angle at the pole, — called also the time or hour angle, is now known from the standard time established, and the *equation of time* as given in the nautical almanac.

From standard, which is mean time, and the equation of time, *apparent time* is readily deduced, which at 15° per hour gives hour angle for any instant between the meridian of the observer and that of the sun, or star, as seen from the pole.

The question is to deduce from these data the bearing of the sun, as seen from the observer.

This will require a knowledge of our latitude and of the sun's declination approximately, and of our *local apparent time precisely.* Though the azimuth is a function of the three elements, it depends most immediately on the time angle.

If we know the latitude to a few minutes, or one-fourth of a degree, it is quite sufficient. The sun's declination is given precisely in the nautical almanac, but if we have it for the second or third year after leap-year, it is sufficiently precise for any of the four years, for ordinary work.

The importance of precision in the apparent time, is seen by consulting the tables of time azimuths, in use by navigators.

By these it will be seen that when the sun is near the meridian, the rate of change of azimuth is much more rapid than when farther away. Thus, in our own latitude of say 42°, with declination 20° N., the sun changes azimuth 10° in the first 15 minutes of time from the meridian, or 40′ of azimuth per 1 minute of time.

At 2 hours from the meridian, the rate is reduced to 20′ of azimuth per 1 minute of time.

Also, the rate of change is reduced by increase of distance from the Prime Vertical. Thus for lat. 42° N. with declination 20° S., and for time angle 4 hours or 60°, the rate of changes is only about 10′ per 1 minute of time, whence, *the best results are found with the sun as far from both meridian and Prime Vertical, as practicable.*

The problem of finding longitude is not difficult, now that the whole country is surveyed, and land-marks established. Every light-house around the entire chain of lakes and rivers, and coast of the country, is an *illuminated land-mark*, whose co-ordinates of place are given, and recorded, to the nearest second of arc, and are furnished for the asking to all owners and masters of American ships.

In the interior of the country, every observatory is a point whose co-ordinates of place are known; and the topographical surveys of the country have determined the location of many other places.

The Government surveys afford the means of counting distances, so that from them the difference of latitude and the difference of longitude can be computed, by knowing the lineal value of these elements for the locality. Then the application of the equation of time gives us *local apparent time.*

I give herewith a table showing the length of one minute of longitude, in statute miles, at every one-half degree of latitude, from 30° to 60°, from which distance east or west, or departure, as we may call it, may be readily reduced to minutes of longitude, nearly anywhere in the United States.

I also give a list of places with their co-ordinates, as taken partly from the "Government List of Lights," partly from "Prof. Winchell's History of Michigan," and partly from "Henck's Pocket-Book." From these, and the Standard Time, which may be readily known to the fraction of a minute, it will not be difficult to find the local apparent time to a good degree of precision.

This being known, the following equation will give us the azimuth corresponding to any assumed time angle, for any latitude and declination.

$$\text{Tan } Z = \frac{\sin H. \cos D}{\cos H. \cos D. \sin L \mp \sin D. \cos L}$$

In which Z = azimuth desired, H = time angle, D = declination, and L = latitude.

The above equation solves the case of spherical trigonometry, —*given two sides and their included angle to find the other parts*— but by a process very different from that given in our text books.

A reference to the accompanying diagram, with a little discussion, will show how the equation was derived, and show the office of each part.

I have written on the several lines their names, so that little further explanation will be needed.

It will be observed that the upper half of the figure represents the plane of the *meridian*, while the lower half represents the plane of the *horizon*, the two planes being at right angles to each other along the lines "North" and "South."

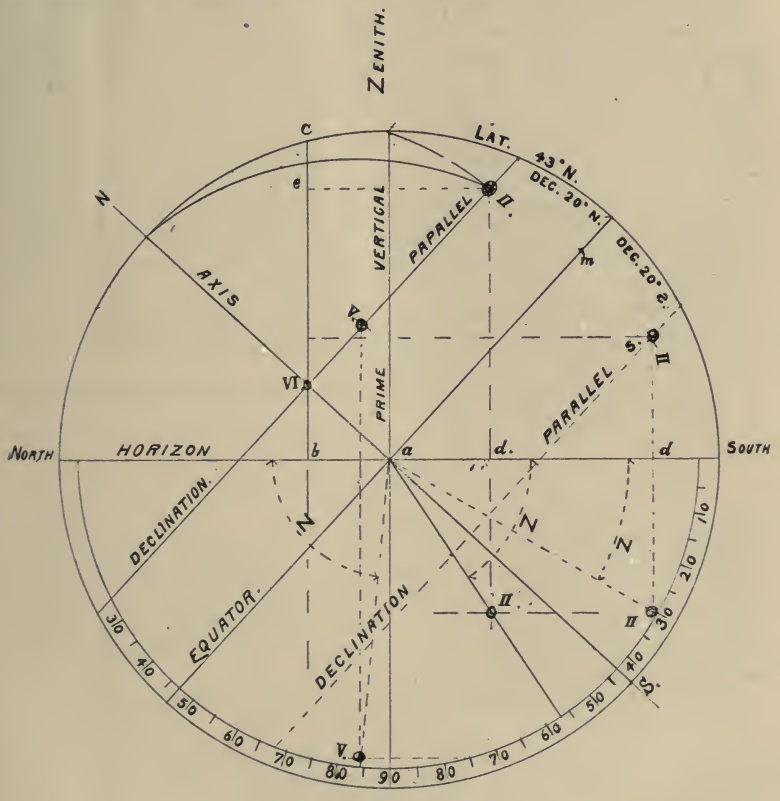

DIAGRAM.

CONSTRUCTION OF THE EQUATION.

The problem is to locate the projection of the sun, or other object, on the plane of the horizon, for any instant of time, whence its bearing is found.

The example projected is for L = 43° N., D = 20° N., and H = 2h. or 30°. Required Z.

It will be observed that the sun, bating the effect of change of declination, travels in a small circle, whose radius is the cosine of D. Also that the projection of the sun on the plane of the me-

ridian for any H or time angle, is the cosine of H on that radius, whence *cos H. cos D.* represents the distance of the sun from the earth's axis, measured along the cos D. (See Diagram.) So that at H = 30°, the sun is seen on the plane of the meridian, at II.

Multiplying cos H. cos D. by sin L, we have *cos H. cos D. cos L* = distance E II., which is the distance of the sun from a plane perpendicular to the plane of the horizon, parallel to the plane of the Prime Vertical, and passing through the center of motion at VI. Thus we have the first part of the denominator.

But we wish to refer the place of the sun to the plane of the Prime Vertical. By looking at the figure, we see that this distance for north declination is too great by the distance *ab* = sin D. cos L., though for South D the distance *ab* must be added. Whence the distance of the sun from the plane of the Prime Vertical, as sun projected on the plane of the horizon, at *a* = cos H. cos D. sin L = sin D. cos L.

The distance of the sun from the plane of the meridian, is the sine of H in terms of the radius of the declination parallel, or as sun from *d* = d II. = sin H. cos D.

Thus, from a well-known property of the plane right triangle, we have, for angle *ad* II. = Z,

$$\text{Tan Z} = \frac{\text{sin H. cos D}}{\text{cos H. cos D. sin L} \mp \text{sin D. cos L}}$$

which is the desired equation.

With L and D of the same name, the declination parallel in which the sun moves will always cross the Prime Vertical *in less than six hours* from meridian. Thus, in our example, it crosses that plane before 5 P. M. or 8 A. M., and the projection of V is seen at V′ on the north of the Prime Vertical, and the angle Z is measured from the north, as shown.

I have shown the place of the sun for S declination, and H = 2 h. at II′ and II‴.

I think the student will have no trouble in apprehending the full idea of this problem from the preceding explanation, which may be open to the objection of being more diffuse and elementary than good taste would warrant. But as this is a new solution of the problem, I wished to be sure of being understood.

The one objection to this method, is the necessity of great precision in the finding of the *local apparent time*, and the consequent error of the watch. But the advantages are many.

We require no expensive instruments, as "*Solar Attachment*" for transit, and no sextant. We have to make no observations for latitude, as we can find that element near enough, from maps; no corrections for refraction, or semi-diameter.

The surveyor should make his computations beforehand, and note the time by his watch, when the sun is at any given distance from the meridian, with the corresponding azimuth.

He should set his Z angle off to the *left* of the zero of his instrument plate in the forenoon, and to the *right* in the afternoon; then, a few minutes before the time for an observation, direct his telescope to the sun, and keep it there by means of the motion on the spindle, the plates having been clamped. At the time the watch indicates the given time for which the azimuth was computed, clamp the spindle motion, and turn the plate vernier back to read "O," *when the telescope will be in the meridian.*

A little practice will make the observer expert in this matter.

Following is the numerical work of the above example, which we have treated graphically: —

L = 43° N.	Cos. (H = 30°)	Log. 9.93753	To find Z	
D = 20° N.	Cos. (D = 20)	" 9.97298	Sin. (H = 30°) =	9.69897
H = 2h = 30°	Sin. (L = 43)	" 9.83378	Cos. (D = 20) =	9.97298
Corresponding number = .5550		= — 1.74429		— 1.67195
			.3049 "	— 1.48416
	Sin. (D = 20°)	" 9.53405	Tan. Z.	= 10.18779
	Cos. (L = 43)	" 9.86423		
Corresponding number = .2501		= — 1.39828	Whence	
Divisor = .3049			Z = 57° 1′	

LATITUDE AND LONGITUDE OF A FEW PLACES IN MICHIGAN AND VICINITY.

Place.	Point of observation.	Latitude N.	Longitude W.
Lake Survey.			
Little Traverse	Light.	45° 25′ 07″	84° 58′ 05″
Charlevoix	"	45 19 15	85 15 21
Manistee	Pier Head Light.	44 15 00	86 20 37
Muskegon	"	43 13 39	86 20 08
Grand Haven	"	43 03 30	86 20 30
St. Joseph	"	42 06 47	86 29 19
Michigan City	"	41 23 21	86 54 22
Chicago	"	41 43 21	87 36 35
Milwaukee	"	43 01 36	87 53 51
Escanaba	"	45 44 40	87 02 30
Marquette	"	46 32 48	87 22 35
Duluth	"	46 46 49	92 05 11
Prof. Winchell.			
Detroit	St. Paul's Church.	42 19 46	83 02 23
Saginaw	Light-house.	43 38 38	83 50 54
Ann Arbor	Observatory.	42 16 48¼	83 43 43
Niles	Trinity Church.	41 49 46	86 15 37
Traverse City	Pier Head.	44 46 00	85 36 53

VALUE IN STATUTE MILES OF ONE MINUTE OF LONGITUDE FOR EACH HALF DEGREE OF LATITUDE, FROM 30° TO 60°.

Latitude.	Miles.	Latitude.	Miles.	Latitude.	Miles.
30°	.9991	40°	.8842	50°	.7422
½	.9940	½	.8778	½	.7345
31	.9889	41	.8712	51	.7268
½	.9837	½	.8646	½	.7190
32	.9784	42	.8579	52	.7111
½	.9731	½	.8512	½	.7032
33	.9676	43	.8443	53	.6952
½	.9622	½	.8375	½	.6872
34	.9566	44	.8305	54	.6790
½	.9509	½	.8235	½	.6708
35	.9452	45	.8164	55	.6626
½	.9394	½	.8093	½	.6544
36	.9336	46	.8021	56	.6460
½	.9277	½	.7949	½	.6377
37	.9217	47	.7875	57	.6293
½	.9157	½	.7802	½	.6208
38	.9095	48	.7727	58	.6123
½	.9033	½	.7652	½	.6048
39	.8970	49	.7576	59	.5551
½	.8907	½	.7500	½	.5865
				60	.5778

H. C. Pearson.

President. — "The paper of Mr. Pearson will appear much better to us all when we have it in proper form. When we get it into our report with the tables that are here given, the paper will appear much more useful than it does here."

PINE LAND SURVEYING.

Mr. President and Gentlemen: —

Last summer while at work on the head-waters of the Thunder Bay and the Cheboygan River, a letter from our Secretary was forwarded to me from my home in Saginaw, requesting me to write a sketch of my daily life in the pine woods. The manuscript (with the exception of the date of the completion of the survey) was written during my leisure moments while sitting, "tailor fashion," on my bed in my tent, with a box of stationery by my side.

Before the United States Government disposed of the land in Michigan, surveyors were sent who divided it into sections one mile square, containing 640 acres each. They marked trees on

the lines each way, thus surrounding each section with a line of "blazed" trees, then sold it in tracts of one or more "forties" (that is, forty-acre lots, being one-fourth of a mile square), as the purchaser desired. If he buys less than a whole section, or sixteen forties, he must get the interior lines marked at his own expense.

When a lumber firm wishes to cut the timber on their land, they usually send men to cut out the "tote road," or road on which to draw supplies from the nearest road already built, and build the camps, then send for a surveyor to mark the lines around the land to cut by.

Years ago some firms made a practice of having the camp foreman or some "land-looker" (a man who makes a profession of examining wild land to estimate its value) run the lines with a small hand compass, and sometimes measure the distance with a pole or tape; but more commonly by "pacing," stepping off the number of steps that experience teaches him will make the required distance. Different men take different numbers to make the same distance, as some take longer steps than others; but in the last few years, "stumpage" (the value of standing timber) is so much more valuable that owners of adjoining land are watching so closely that it does not pay to take the risk of having to pay for timber cut on the land of other parties.

When the foreman sends to the office of the company, that he is ready for the surveyor, that he "must have him at once, cannot wait," as is usually the case in Saginaw, if the same call comes from a dozen or more camps at about the same time, the surveyor is at his wits' end to know how to do all the work. He surely cannot do it all at once, and he does not want to refuse any; so he makes all sorts of promises, to put off those he cannot accommodate first, usually promising to go from one camp to another nearest to where he does his first work. He takes his compass and chain, and goes to the nearest point reached by public conveyance, and if he is so fortunate as to meet the "tote team" from the camp, he will ride to camp on a load of supplies, or, as is frequently the case, if the road is so rough that it is harder work to ride than to walk, he puts his tools on the load and walks behind, usually getting into camp at night. He makes himself known (if he is a stranger) to the foreman, and asks for help for the next day.

The camps are now usually built so as to have one building exclusively for cooking and eating, with a bed in one corner for the cook and "chore-boy," (it makes no difference what his age is, he is "chore-boy" all the same), and one building for the men to sleep in, with "bunks" on each side and sometimes across one end. They are wide enough for two, and are usually one above another. Stationary seats are made in front of them, level with the lower bunks. At the end of each bunk, is a post of round timber which reaches above the upper bunk, with a one-and-a-half or two-inch hole bored through at the bottom of each bunk, into

which is fitted one end of a round stick, the other being in a like hole bored in the log of the side of the camp. On these the boards are laid which form the bottom of the bunks, with a narrow board set on edge in front and another cut and fitted from this to the log, to form the division between the bunks. The bed consists of a tick filled sometimes with straw, but more often with hay, over which a blanket is spread, and usually two pairs of blankets for a covering, each man furnishing his own pillow, usually the clothing he wears through the day. Sometimes his "turkey," a common grain bag containing his extra clothing, serves for a pillow. Sometimes the bed tick is omitted, and the hay put into the bunk loose.

Towards the door (which is in one end) from the center of the camp, is a large box stove, on which usually stands a galvanized iron kettle filled with half a barrel of water kept hot for washing, and mixing horse feed. The pipe runs up high enough to be out of the way, then turns and runs back of the center, where it again turns and runs out one side of the center of the roof, as there is a large log in the center on which one end of the roof-boards rest, the other end resting on the top log of the side of the camp, and supported in the middle by another large log, running lengthwise of the camp. From one to the other of these, under the stove-pipe, are a number of wires taken from baled hay, on which wet clothing is hung in the evening to dry. The roof-boards are covered with tarred paper instead of shingles, thus making it nearly air tight, and retaining the steam from wet and soiled clothing, the breath of the whole crew, etc. A person entering the room in the night would, with the first breath he inhales, be tempted to retreat.

Next the door, one bunk is left out, as a place to pile wood on one side and for a wash-room on the other. A long sink is made, extending from the door to the corner, with the corner end the lowest, and a spout through the logs to a ditch on the outside. A pork-barrel is set in the corner and filled with water, into which the wash dishes are dipped for washing; and by the time forty or fifty men wash, and wipe on the two or three towels which are furnished, they are not very dry or clean; consequently it is advisable to carry a small towel in your pocket for your own use.

In most camps there is a small building for an office, in which is kept a stock of clothing, tobacco, and other things that may be needed, to sell to the men during the winter. These are kept on shelves at one side, near the door, in front of which is a counter. In the back end are beds for the foreman, clerk (if they have one), scaler, and visitors. Here the surveyor usually sleeps; if not, he must sleep with the men in the other camp, and take the consequences, which are not always pleasant, as the blankets sometimes contain undesirable bed-fellows.

About five o'clock in the morning, the chore-boy blows a tin horn, which is from four to six feet long, and can be heard for

miles. This is an invitation to get ready for breakfast, and gives the men time to dress and wash, when a single blast of the horn announces breakfast ready, on the table, and getting cold; and he who wants it warm must get there to eat it.

No talking is allowed in the "cook-camp" at meal time. Each man has his particular seat, rushes to it, helps himself to whatever he wants, if he can reach it, if not, asks his neighbor in a suppressed tone to help him, eats as though a fortune depended on his finishing the meal in so many minutes, and is on his way to the door before he swallows his last mouthful.

This is a description of camps as they are now built, where saw-mills are convenient to secure lumber, and transportation facilities are ample to carry in stoves, etc.; but years ago the camp was covered with "shakes," thin pieces of pine split from a log about three feet long, and laid from one pole to another, which usually (but not always) kept out the rain. But "shakes" offered no resistance to the wind, or the drifting snow. There was also a "caboose" in the center, made of logs ten or twelve feet long, forming a square, notched into each other at the ends so as to be level with each other. This was filled with sand, on which the fire was built, frequently made of half a cord of hard green wood. There was a hole in the roof for the smoke to escape. When the fire burnt down, it left a large mass of bright coals, over which the food was cooked, the cooking and sleeping being done in the same room. The bread and beans were baked in the "bean-hole," a hole dug in the corner of the caboose, with some live coals and hot ashes and sand put in the bottom. The bread or beans were put into an iron pot with a tight cover, which was set in, then covered with hot coals and ashes, and left until properly cooked; in the case of beans, all night. At that time the men were less liable to sickness than now, as they were sure of plenty of fresh air, the only adulteration being smoke and ashes, which were frequently more plenty than pleasant.

The foreman will detail as many men as the surveyor wants, usually one axman and two chainmen, from those he can best spare. If he has any that are good for nothing else, he will send them, as all the best men have work that must go on. He usually goes with the surveyor to some corner on the Government survey, then leaves him to find the rest himself. Where the brush is not too thick, the surveyor goes ahead, keeping one eye on his line, and the other on the chainmen, followed by the axman, who is ready to cut the way through any obstruction too thick to pass without, the chainmen bringing up the rear. The first time through on a line as few marks as possible are made, setting temporary "tally-stakes" at the end of each five or ten chains, according to whether he uses a half chain or a chain (thirty-three or sixty-six feet); and when he gets through to the next Government corner (he should seldom, if ever, assume a corner set by some

other surveyor to be correct), one-half mile or one mile as the case may be, note in his field book the entire distance between the two corners according to his chain as well as the links, to right or left, and the bearing of the random line according to his compass; then correct his bearing and run back, setting the tally-stakes over, *pro rata*, and marking the trees between, thus leaving nothing behind on the random line which might mislead the choppers, while cutting the timber. If a corner is to be set between the two corners measured from, set a temporary post at the proper distance on the random line, and then set it ahead or back, as well as to right or left, *pro rata*, as the section over-runs or falls short. Thus it makes no difference whether his chain is standard length or not. It is practically impossible to keep a chain the standard length, that now used by the writer, one of Gurley's best tempered steel brazed chains, now being 66.58 feet, instead of 66 feet, as it was when first made. Where specified distances are required (which is seldom, if ever, in pine land surveying), the chain, if used, should be tested at the time with a good steel tape, and the proper correction made in the entire measurement.

If, in making his survey, he should find where some owner of adjoining land had cut across the line, whether in consequence of a line not properly run, or from any other cause, most lumbermen require the surveyor to measure the trees so cut, and report to them, which is done by measuring the diameter of the stump, or in case the butt of the tree is defective and left on the ground, the diameter of the top of the piece so left, the diameter of the top of the tree where cut off, which is the diameter of the top of the timber taken, and the distance between, which is equal to the length of the tree. This length he divides into logs of the usual length (as many 16 feet long as possible, the balance 12, 14, 18, or 20 feet), the diameter of the top subtracted from that of the butt. This number divided by the number of logs in the tree, and the quotient (as near as possible, avoiding fractions) added to the diameter of the tree, gives the diameter of the top end of each successive log. Then from his "log-book" or scale-rule, he puts down the number of feet, board measure, in each log, the sum of which gives the number of feet in each tree. He should mark a number on each stump in some substantial manner, cut with a "timber scribe" is the best, and mark the same number on his book for future reference, should his measurement be disputed. It has been the practice of the writer to make his report in a tabular form, giving in the first column the number marked on the stump; next, the diameter of the butt; then of the top, in inches; then the length of the tree in feet; and last, the feet, board measure, in the tree, or "scale," prefaced by a statement of the date of measurement, the date, as near as possible, of the trespass, what particular forty-acre lot, on which side, and stating that it was cut by parties lumbering on a specified piece of land, making the report in duplicate, and his employ-

ers usually keeping one copy in the office and sending the other to the parties who cut the timber (if known). They can, if so disposed, have the lines re-surveyed, and if found to be erroneous, throw out any particular tree without affecting the balance of the report, as well as test the measurement of each tree separately.

When going to camp, if the surveyor does not meet the "tote team" from that camp, or some other near, he must walk to camp, carrying his tools; and when done at one camp, he usually has to walk to the next, frequently through the woods, and without any guide but his hand compass, which the writer is never without, at home or abroad.

This class of work commences in the fall as soon as the camps are built, which is usually in September or October, so as to get the roads made and most of the timber cut and skidded before deep snow comes. Then when good sleighing commences, there is little to do but to haul the timber to the bank of the streams, ready to float to the mills in the spring. About all the calls a surveyor has after that, is in case the owners have reason to think some one has trespassed on their land. Of course, when the snow is deep, it makes hard and slow work, and as little of it is done as possible. This time varies with different seasons, from the middle of December to the first of February.

In the spring of 1887, a firm of Saginaw lumbermen ordered the writer to make a survey of a large tract of land which they owned. There were nearly 40,000 acres of it, located in townships 26 to 36 north, ranges 4 west to 5 east. In the whole tract there were only three whole sections. It was scattered through 272 different sections, in 43 townships and 7 counties. I had already surveyed enough to furnish two seasons' cutting, besides some that was cut over some years ago. As there were settlers all through the townships, and roads already made, I made no preparations for packing, but depended on going with a team wherever we went with the camp.

I bought one "two-men tent" for the cook and teamster, and one tent nine feet square with two feet wall, in which I slept with my two chainmen and two axmen. We put a pole across about 2½ feet from the front, held by stakes, for a "foot-board," leaving a space in front for "turkeys," boxes, boots, etc. For the bed, we picked a large quantity of hemlock twigs, keeping the stems together, then commencing at the head of the bed, laid a layer of them, then another a little back, with the stems on the ground, and the tops on the first layer, and so on till the ground was covered, when nothing was to be seen but the leaves on the end of the twigs. Over this, two strips of oil-cloth were spread, covering the twigs. Then the three beds were furnished with four pairs of blankets each. During the coldest of the weather we used three pairs of blankets over us and one under us, but most of the season, two pairs over us were sufficient. There were but very few nights

during the season that two pairs were too much, as the nights were nearly always cool.

To the front of the tent we pinned a piece of mosquito netting, doubled, with the bottom resting on a log which was staked against the front of the tent. This excluded the mosquitoes, but not the gnats. But by building a small fire in front, they were attracted to it and burnt, thus leaving us to enjoy a good night's sleep undisturbed. We had another "two-men tent," in which to store our supplies. We took a board sixteen feet long and sixteen inches wide, and cut it in the middle for a table, which made it eight feet long by thirty-two inches wide. We drove four crotches into the ground with sticks between each pair, under each end of the table. For seats, we drove four shorter crotches with sticks across under the table and a board on each side. At each end of the table was a crotch about nine feet high, with a pole from one to the other. Over this was thrown an awning nine feet by twelve, with ropes at each corner, which were tied to stakes about five feet high, thus protecting the table from rain or sun. An oil-cloth was spread over the table on which the dishes (of tin) and prepared food were left, and covered with another oil-cloth when not in use. The cooking was, of course, done wholly outdoors, the bread and beans baked in a "bean hole" dug near the fire, in the old "caboose" style. We had our mail sent to Gaylord, Otsego County, and when nearer some other office, had it forwarded to us.

I took the Saginaw Daily *Courier*, which kept us posted on the doings of the outside world; but sometimes we would be where we could not get the papers for a week or two, and at one time, three weeks, then we got them all at once.

We left Saginaw April 25, and returned Sept. 12. On Sept. 19, I went back to the lumber camps with one axman and two chainmen, and remained till Dec. 21, when the snow was too deep to work to advantage. April 30, 1888, I started out again with my camp equipment, and remained till Sept. 19, when I completed the survey of the land. I purchased most of my supplies in Saginaw, and had them shipped to Gaylord, where my team went for them. Some things (especially potatoes) I bought of the settlers. Potatoes are the principal crop raised by them, as they can raise potatoes with much less labor, and of a much better quality, than farther south. They expect (and usually get) a frost every month in the year, thus killing many weeds that trouble the farmer farther south.

J. H. Leavenworth.

President. — "The object of the writer of this paper is not to instruct us how we should run a line, but it is to get into our report the ways of doing this work, and all those little attendant incidents which have occurred and are occurring, but which are fast passing away. The running of these lines will soon be a thing

of the past. It is and should be our object to gather together all these little incidents of what we might properly call pioneer work in this class of work, and all those little incidents of camp life which will soon be forgotten by many, and store them carefully up for future use as a history of how work was once done in our northern Michigan woods."

Mr. Rogers. — "I would like to ask how to get the length of a tree after it has been chopped, and the logs cut and removed?"

Mr. Leavenworth. — "I always instruct the man who holds my tape line to hold it just about where the butt has been cut off, and then measure to where the top is cut off; and then in estimating the number of logs, I never make calculations in odd feet, as I know that logs in the country are always cut in lengths of even feet, and never cut into odd lengths, so if there is a variation of a little, we can always get it pretty accurately."

President. — "I was employed at one time in finding out how much timber had been removed from a certain piece of land that was then in controversy with reference to a trespass suit. These lands were mostly covered at one time with pine timber, but there was scattered through it hemlock, beech, and other varieties of timber, so that we had a considerable timber to work among. It was our object to get every tree, so we had to be very careful in our work. I managed with two men besides myself, and with the aid of a pocket compass and blazes, to get every tree. It was quite a difficult task, at each time as we crossed the land east and west, in some places over a mile long, and others only a quarter of a mile long, to indicate our path by means of the blazes; and it was a great surprise to me that I could find the butt and top of every tree that had been cut, although it had been three years since the timber was removed. By observing very closely, any one can see by the splinters on the stump which way the tree must have fallen, and where it struck the ground; or what is the best guide of anything, the sawdust piles where each log had been cut off at intervals of the length of the logs; and by measuring the diameter of the butt and the top, and the number of logs taken off, you could calculate very closely the number of feet there must have been in the tree."

Mr. Leavenworth. — "I have generally made a practice, especially where there is much underbrush, of following log roads, and keeping either to the right or left; and I found I was always pretty successful in getting the trees by that means."

Secretary. — "I want to speak a few words on the subject of land surveying. I see many new faces here with us, and I have understood there has been a feeling of disappointment expressed by some on account of not having more papers on the subject of land surveying and kindred subjects. Of course, they do not understand the amount of this work that has been done by the

Society. When we first started out, our work was mostly on land surveying. Afterwards, on account of the large number of engineers joining our ranks, we devoted a considerable time to subjects of interest to civil and mechanical engineers, and so we have had to diversify our subjects as much as possible. About 40 per cent of our work up to this time has been in the direction of land surveying, while not that percentage of our members are simply land surveyors. We have traversed the ground so thoroughly in that line that it is very difficult to bring up any question on the subject of land surveying that would be new. When I was preparing a programme for this session, I sent out circulars to the members for topics on the various subjects, and out of that whole lot there was but one gentleman who suggested a topic on land surveying.

"Now there is but one thing that is of particular interest to me in that direction, and that is the decisions of the courts on points connected with our practice in land surveying.

"These decisions can readily be secured by the Society through the American Digest referred to in my report. While on this subject, it may perhaps be as well to call to your attention a recent decision of our Supreme Court. You will remember that at our last meetings I took occasion to criticise some of their decisions, particularly in the cases of Wilson *vs.* Hoffman, Keyser *vs.* Sutherland, Palmer *vs.* Dodd, and Commissioner of Thompson Township *vs.* Beebe.

"In the first case, it was decided that a fractional lot, as sold by the United States Government, could not extend beyond a quarter line. This was re-affirmed in the two following cases. Since my criticism of the doctrine was published, the Supreme Court has ordered a rehearing of the case of Wilson *vs.* Hoffman, and they have changed their former ruling on this point. Here is what they say about it, taken from the thirty-eighth 'Northwestern Reporter,' p. 558: —

"'In this case, when formerly here, the map of the original survey was not so certified as entitled it to be received in evidence, and there was nothing in the case as then presented that showed that the premises described in the declaration, came within the description of the S. E. quarter of Section 28. In the record before us this has been obviated, and the copy of the original plat of the township has been introduced, which shows, according to the Government survey, that the premises in question are embraced in what the Government denominated the S. E. fractional quarter of Section 28, in its patent to Tingley. It might perhaps have been more accurate to describe it as that portion of Section 28 lying south of Black River, but as the fraction contained less than 160 acres, and the law required it to be sold entire, the description contained in the patent was sufficient, and is quite

a customary method of description in the general land office. The conclusion of law which the court below arrived at, so far as it holds that the facts of this case as now disclosed are not contained in the claim embraced in the declaration, is erroneous.'

"It is gratifying to find that, like the Supreme Court of the United States, our own Court deems it better to break away from a precedent, or as in this case, from a line of precedents, than to adhere to an erroneous decision. Since coming here, I have taken pains to look up the original field notes of the section involved in the case of the Commissioner of Thompson Township *vs.* Beebe, and have also examined the full report of the decision in the case. The report does not disclose the fact whether or not there were two sets of section corners on the Range line, but from the surveyor's claim that his line was right, and that the quarter line as he ran it came out some ten or twelve rods from the quarter post for Section 36, one would naturally infer that there were double corners on the township boundary. Such, however, is not the case. The subdivisions were surveyed under the modern instructions, by which the closing lines of the survey are required to close on the standard corners. The line between Sections 30 and 31 was run west as a random line, to its intersection with the range line, and then corrected back for true line. Under these circumstances, I am disposed to accept the decision of the Court as correct, and to recall my former criticism, which was based only on the facts disclosed by the report of the case. I think the Court was right, and that as there is only one set of section corners in the boundary lines of townships, surveyed under the modern instructions, there should be only one set of quarter-posts."

Mr. Watkins. — "I differ with the Supreme Court and brother Hodgman in the matter. I say the Supreme Court is still in error, and I think I can show it to you. Supposing the section corners correspond, but the quarter post is not exactly in the center between them. I have sometimes found it half a chain out of the proper place. Now, if the Government survey is wrong, are we to perpetuate the error in another township because there is an error in the first? — I say most emphatically, No! But I think the subdivisions of each section should be made to depend upon the corners in that section. And where we find the measurement of either one of the lines over 80 chains, give each quarter half of it."

Secretary. — "The surveys in question were made under the instructions of 1855, and in these same instructions it is stated that there are to be double corners nowhere, except on the base and standard lines. Now we had no double corners there, and I cannot see how we can make any."

Mr. Watkins. — "The surveyors should do justice by the parties employing them, and where they have not made corners, we should make them."

Mr. June. — "If the east quarter post is here, and the new quarter post should be set east of it, and on land that is not in controversy at all, which shall be our guide?"

Secretary. — "It has been settled that the township boundary line, where it was run by the United States surveyor, shall be conclusive."

VILLAGE PLATS.

Nearly every engineer is from time to time called on to make a survey, and plat the part or whole of a village. Those who have had experience, will not profit to any extent by my remarks, as they will be familiar with the subject from every stand-point. I have little reason to think that the members of the Engineering Society here had extra work to do because of the law, excepting myself. I have no doubt that your extensive practice was sufficient to enable you to take in at a glance all the fine points of the law, and consequently no plots were ever returned to you for correction or addition. With myself it was not so. My first attempt, although correct in my own mind, was not in harmony with the legal requirements as interpreted by our Auditor General. I afterward came to the conclusion that he and not myself was correct. These few words are written, then, entirely for the benefit of young engineers, and explain the process in detail, as concisely as possible. A circular containing the law and certificates can be had by addressing the Auditor General at Lansing. The process is as follows: —

Procure three sheets of muslin-backed paper, each 18 x 24 inches in size. The first of these will be termed the original drawing, and must be submitted for approval, as soon as completed, to the Auditor General. This must contain the certificate of dedication from the proprietor, a description of the land platted, and the surveyor's certificate. This, after being approved by the Auditor General, will become the property of the proprietor.

An exact copy of this plat, with the addition of a certificate of comparison to be signed by the Register of Deeds and the surveyor, for filing in the office of Register of Deeds of the county, must then be made. This second copy must contain a copy of the Auditor General's indorsement of approval. Still another exact copy must be made, containing all the certificates of the second copy, and in addition, one signed jointly by the surveyor and Register of Deeds, as to its exact agreement with the second copy. This is sent by the Register to be filed in the office of the Auditor General. The above is the general outline of the law, and should be fully comprehended before the details of construction are attempted. Indeed, I think most of the trouble experienced has come from not realizing the use and necessity of the three copies.

The details required are clearly set forth in the circular issued by the Auditor General, and I doubt that much trouble has been caused on that account. The principal on which these requirements are founded is the reasonable one that either map or description shall be complete in itself, and further, that a sufficient number of dimensions shall be put on the map to preclude any necessity of using a scale. This gives two or three checks on the correctness of the work, and would be valuable in detecting any error in any one of the methods. To carry this out, first our plat should show a complete and full description of the area to be platted; secondly, our map should be accompanied with a scale and meridian, and should show the location of all fixed monuments; thirdly, distances should be written on the map for each boundary line, for the width of lots and streets, and for the dimension of the scale. Our present law requires permanent monuments at all street intersections, and at each change of direction in the boundary line. The monuments at street intersections are not required at the center of the streets, or in any other specified position. The surveyor should use his judgment in locating his monuments, so that they will not be likely to be removed in making village improvements. The borders of the streets, or the curb lines, are not so likely to be disturbed as the center, and would answer every purpose in most cases.

It should be noted in making the second and third copies, that the law requires them to be exact copies of the original. This does not mean equivalent copies; and if the Register does his duty, every figure and word on the original must find its counterpart in the copies.

A form of certificate for the original and the copies can be had from the Auditor General's office. It would save much work if our prepared paper for plats could be had with these certificates printed in black on the sides. I believe there would be demand enough for each form to make the printing of them profitable. I would suggest that our worthy Secretary take the matter into consideration.

Just a word in regard to the appearance and construction of plats, and in this respect I will give you merely my own opinion. In the first place, these are merely maps, and clearness and distinctness should be the first and most important characteristic. The map should not be buried under a mass of pictures and fancy penmanship. The title should be clear and conspicuous, but not too prominent; and it would suit me better if plain. All the lines should be perfectly black, of even width, and thick enough to show well. The street names, figures, and dimensions should be neatly printed in black. I think no ink but a good quality of India ink, should be used for lines or dimensions. Tints can be easily applied, and if of neutral colors, will look well. As to a border, I prefer simply two plain black lines of different weights to any complicated arrangement of chains, vines, etc.

In regard to inks, I merely wish to say that liquid India ink of good quality can now be had. The Higgin's inks are the best prepared in this country, so far as I can find. These may be had in water proof ink for tinting over, or plain for other purposes. A French liquid ink, marked with two dragons, seems to be better than our American inks. The liquid inks are more costly than the stick inks, but are much more convenient to use, especially when no considerable amount of drafting is done.

PROF. R. C. CARPENTER.

HOUSE DRAINAGE.

THE progress of sanitary science during the last decade has been remarkably rapid. This has been largely due to a division of engineering labor and a concentration of the energy of able specialists in this field. No dwelling of any pretensions is now considered complete, or even looked upon with favor by a prospective tenant, unless it is fitted with "modern conveniences." These appliances are entirely proper and safe if the work is entrusted to proper hands. It is hard to conceive of a class of work, however, in which wrong methods or poor work are more detrimental, or the resulting influences more insidious.

In a paper of this kind, little more can be attempted than generalities. Methods of work are largely influenced by particular conditions. The condition of the public sewers, the methods employed for their ventilation and cleansing, and the rules of municipal Boards affecting the citizens, are all to be considered. The tendency at the present time is to refer work of this kind of any considerable magnitude, to specialists.

House drainage in its broader sense means both the removal of the liquid waste and whatever it carries with it, and also the removal of the subsoil water and storm water. Indeed, what is often spoken of as house drainage is strictly house sewerage. House drainage is the removal of water which has not been fouled.

The principal distinction between a sewer and a drain is that the former, being for the conveyance of foul liquid, should be absolutely tight, so that none of the contents may be lost by the way, and no vapors escape. A drain, on the contrary (as for instance a subsoil drain), must be laid with open joints, so that, the pressure being from without, it will receive the ground water all along its course, and remove it. The functions of the two are distinct. When both kinds of drainage are necessary, it is best to keep each system distinct. When a general system of sewerage is already constructed without regard to subsoil drainage, the householder frequently has no option but to connect the drainage system with the sewer proper. A very good method in such a case is to make the connection

through the medium of a deep seal trap where the street sewer enters the house. This connection should be through an iron pipe, properly calked into the trap, and provided with a brass-seated check valve which will prevent the sewage from filling the subsoil drains, in case the street sewer becomes obstructed. The subsoil drains should be of small agricultural tile laid well below the cellar bottom, and the joints properly protected. The sides and bottom of the cellar or basement should be thoroughly damp-proof. I am aware that this point is generally overlooked. We do not stop to consider that the earth below and about buildings is a great collector and retainer of filth, and that it is sufficiently porous to admit of the passage of air currents in considerable volume, especially under the influence of furnace draughts or other like causes. The action is not unlike what would occur if we suppose the house to be set on a sponge 50 x 100 feet, for instance, to which we constantly apply a stream of foul liquid, and then induce upward currents through the house by the action of heat. The cellar walls and floor can be very easily and cheaply made damp-proof and air-tight by a coating of some preparation of asphalt.

The main drain for ordinary dwellings should be four inches in diameter, and laid with as much descent as possible. The inclination should not be less than one in fifty. The method of connecting the main drain with the soil pipe depends upon the method of ventilation. The simplest method is to extend the main drain upward and out through the roof, unbroken by a trap in any portion. In this case it serves the double purpose of soil and ventilating pipe, and the air which passes into the street sewers at man-holes supplies the draught upward along the street sewers, and out through these and their upward extensions. In this case, the isolation of the interior of buildings from sewer air depends solely upon the trap under each fixture. Where street sewers are properly constructed on the "separate" system, and properly cared for, this method has proved entirely satisfactory. It certainly has great advantages in simplicity and facility of arrangement.

Where the sewers are built on the combined plan, the method of isolation shown in Fig. 1 is to be preferred. This diverts the foul air currents from the interior pipe, and provides a supply of fresh air for the upward current through the soil and ventilating pipe. If the street sewers are not properly ventilated at frequent intervals, either by the upward extension of exterior or interior unobstructed pipes or otherwise, there may be reasons for believing that an isolated one may draw from too wide a territory, and prove offensive. In this case, it is advisable to dispense with any vent pipe communicating directly with the sewer.

The main drain within or under the house and for a few feet outside of it should be of iron pipe with lead calked joints. It is better to fasten it along a wall by iron brackets or hangers above the cellar bottom, if possible, giving it as great an inclination as is

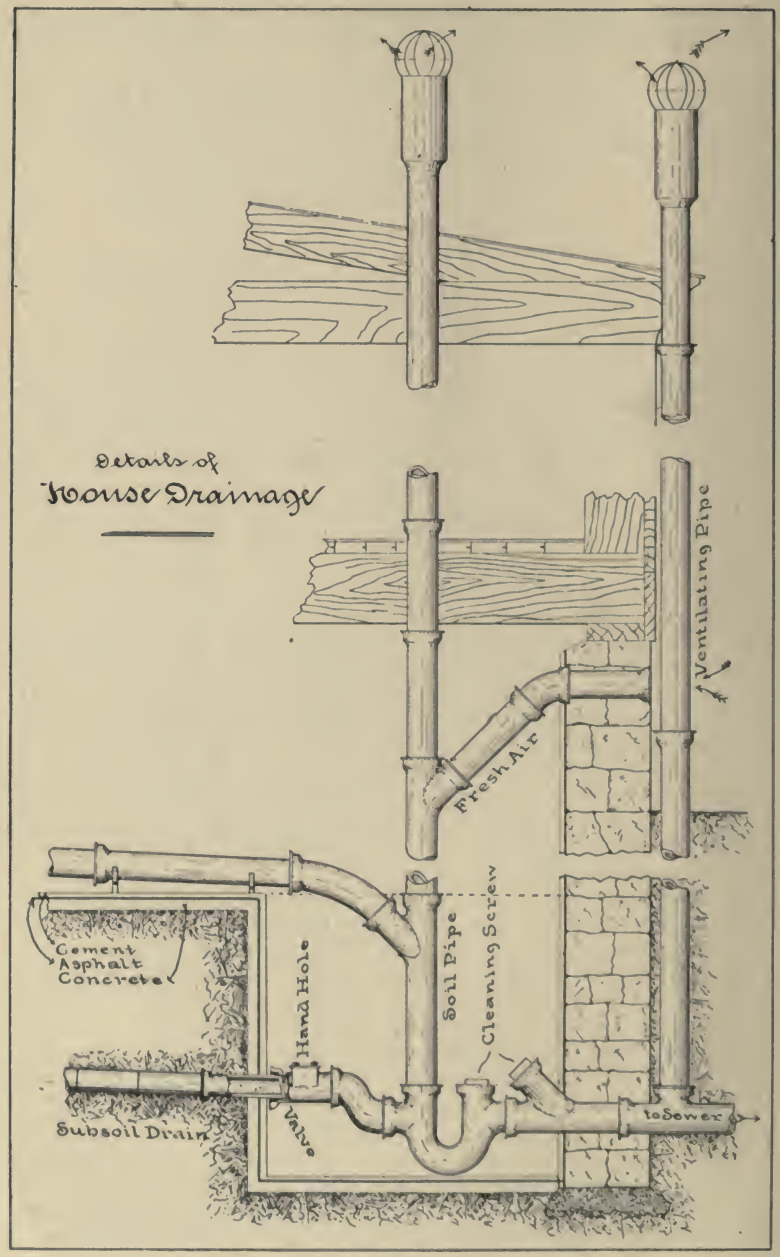
Details of
House Drainage
Ventilating Pipe
Fresh Air
Cement
Asphalt
Concrete
Hand Hole
Soil Pipe
Cleaning Screw
Subsoil Drain
Valve
to Sewer

FIG. 1.

permissible. In some cases it is necessary to place it below the basement floor on account of fixtures in the basement. This should be avoided if possible. Removable hand-holes or brass cleaning screws should be provided at intervals, through which obstructions can be removed. All iron pipes and fittings should be thoroughly coated outside and inside with coal pitch varnish applied hot.

A very common fault is to make the upward extension of the soil pipe, after it passes the highest fixture, of galvanized sheet iron, or even of tin. This is highly objectionable. It should be of heavy iron pipe throughout, and should extend well above the roof. It is a good plan to increase it in size above the roof to six inches, so as to lessen the danger of its being obstructed by the accumulation of frost. Ventilating cowls are of doubtful utility. A plain wire basket to prevent the introduction of articles liable to obstruct the pipes, is better.

There is such a variety of branches, curves, offsetts, traps, etc., etc., now in the market, that there is no excuse for awkward and rough connections and interior projecting angles or pockets which will retain the solid portion of the sewage. The course of all pipes should be as direct as possible, and the fixtures should be grouped so as to be reached as nearly as possible by upright soil pipes and short horizontal soil or waste pipes. Horizontal pipes cannot be carried any great distance along floors or ceilings or between joists, and preserve a proper inclination, for reasons which are obvious. It is customary to make waste pipes, particularly short ones, of lead, for the reason that it is much more easily manipulated than iron. The proper method of connecting the lead wastes to iron is by means of a brass thimble soldered to the lead pipe, and calked into a hub on the iron pipe.

It is a very bad practice to inclose plumbing fixtures with wooden casings, as is done in a majority of cases. It will surely tend to the accumulation of dampness and filth, and the emanation of unwholesome air. Unwholesome smells which are attributed to some faulty construction or arrangement in the drainage pipes, often have their origin in these inclosed spaces.

It is not uncommon in summer, when the air is loaded with moisture, to see water accumulate in bead-like drops on the surface of plumbing fixtures or pipes which are kept cool by a current of water from a tap, and course downward almost in streams. If the fixtures are not inclosed, they can be readily wiped dry. If inclosed, they receive no attention, and the accumulation of dirt and moisture becomes very offensive.

The better way is to have as little wood-work as possible surrounding these fixtures. The better kinds of water-closets are made so as to require no wood surrounding them, except a cover. A very good way to fit up wash-stands is to support the slab upon brackets fastened to the wall, leaving the under side entirely open, and the pipes,

traps, etc., entirely exposed, or partially hid by a narrow slab placed edgewise under the shelf proper, and extending downward about six inches.

So far as possible, it is preferable to have soil, waste, and ventilating pipes exposed, to having them inclosed within partitions, where they are inaccessible either for inspection or repair. This method of arrangement is not without its influence on the plumber. He is not less inclined to pour lead joints properly, or thoroughly to calk them all around, or to make neat and perfectly wiped joints, than when he knows that the carpenter or plasterer will cover his work within a few hours. I am aware that the average house owner will look upon this arrangement as decidedly lacking in finish, and not in harmony with interior decorations. Neither is a stove pipe, a furnace register, a steam radiator, or a gas fixture. This is largely a matter of education, and possibly we have been wrongly taught. It is not customary, however, to place these fixtures in rooms where any exceptions can be taken to this method of arrangement.

Plumbing fixtures should not be placed in sleeping rooms. They should be confined to the bath room, where special means of ventilation can be employed, and to the kitchen, laundry, and similar rooms.

A multiplicity of fixtures should be discouraged. A fixture rarely used is a greater source of danger than one used frequently.

Particular care should be used in arranging the ventilation of a building, so that the air currents tend to pass outward from the group of rooms containing plumbing fixtures, fresh air being admitted to other portions of the building. The facility with which this can be accomplished, and also the proper grouping of fixtures and simplicity of the system of pipes, will depend largely upon the architect. Ample means should be provided for flushing all portions of the soil and waste pipes and all fixtures. This is most effective when special flushing cisterns are supplied.

The ornamentation of porcelain ware and of surrounding woodwork by raised or carved patterns, is positively detrimental. A perfectly plain, smooth, impervious surface is more conducive to cleanliness. A very usual fault in house plumbing is too many fixtures, too much pipe, too much ornamentation. The owner may have perused the sanitary journals, or have heard some sanitary engineer talk sewer gas until he is thoroughly imbued with the idea that *here* is something which must be done thoroughly, and he not unnaturally comes to think that the more extensive the plant, the more sewer gas will be annihilated.

Every fixture should be provided with a trap, and since the object of the trap is to isolate the fouled interior surface of the waste pipe from the air of the room, it is evident that the trap should be as close to the fixture as possible. Notwithstanding many efforts to introduce a trap whose seal cannot be broken by

syphonage, and which will be self-cleansing, the plain-running trap of uniform bore is still in general use. This trap is liable to have its seal broken by syphonage, and to prevent this it is necessary to resort to a back air pipe, which is connected with the crown of the trap on the downward side, and passes to the roof independently of the ventilating pipe proper, or is connected with it above the highest fixture. This back air pipe should be of ample capacity to preserve the equilibrium of air pressure.

The system of back air vents is open to the following objections: It considerably complicates the system of piping, especially where fixtures are not closely grouped. There is a possibility of the pipes' being fouled at their junction with the crown of the trap. It adds considerably to the expense.

Back air vents tend to increase the interior circulation of air considerably. This is beneficial, so far as purity of the interior of the pipes is concerned, but it also increases the evaporation from traps. This will do no harm if fixtures are in constant use. On the other hand, if special anti-syphoning traps are used, and back vents are dispensed with, there will be little circulation of purifying outer air through the waste pipes.

When the soil, ventilating, and waste pipes are all in position, and before the fixtures are put in place, a test of the thoroughness of the work should be made. This can be done in a variety of ways. The following will be a very good test: Close up the main drain where the iron pipe terminates outside the house wall, also the exposed ends of all pipes where fixtures are to be connected, and the fresh air inlet, if there is any. The ends of lead pipes should be left somewhat longer than necessary, so that this can be conveniently done by flattening them, and closing with solder.

When all openings in the entire system of soil, waste, and ventilating pipes are tightly closed below, fill the entire system with water from above nearly to the top, and mark the hight at which the water stands. If no leakage is apparent, and the water stands at the same level for some hours, the joints may be considered good. The entire work should be carefully inspected while under pressure, and joints re-calked where necessary.

It is not proper to connect waste pipes from refrigerators or safes, or overflow pipes from water tanks or cisterns, directly with the sewers or waste pipes. The discharge from these can be often collected at a common receptacle, however, which is isolated from the sewers by special means.

For the purpose of getting a more comprehensive view of what we have sought to accomplish, let us review it briefly.

In the first place, we have secured a dry basement. This we have not accomplished by the ordinary method of an inlet into the sewer direct from the floor through a trap which is generally empty and provided with a removable strainer, which some servant will displace, and quite likely lose. On the contrary, instead of mak-

ing a hole in the basement floor, so that if it gets full of water, it can run out again (some day), we have sought to keep the level of ground water so low that the tendency will be in the other direction. It is well to design work of this class on the supposition that the worst will happen. Let us apply a few tests of this character, and note the probable behavior of our appliances. Assume, for instance, that it rains and continues to rain until the ground water rises considerably above the basement floor. The tile drains will remove it as rapidly as possible, and (the basement walls and floor being assumed impervious) there is no avenue by which it can enter. There is no trap or valve interposed, by the failure of which such an avenue can be established. The water-proof coating extends not only over the basement floor, but into the trap chamber, and surrounds the traps and soil and vent pipes like a dentist's rubber dam, entirely isolating the interior from whatever may be without. (See Fig. 1.) We may ride out the storm with all the confidence of a seaman in a dry ship. Suppose, again, that the main drain outside the house or the street sewer becomes obstructed. In this case, the tendency will be for the sewage to accumulate in the main drain and soil pipe, and be distributed and diffused through the subsoil drains. Its ingress to the subsoil drains will be prevented by the check valve. Suppose, however, that the check valve does not act, and that sewage is diffused through these drains. The house is still entirely isolated from it by an air-proof coating, and the danger reduced to a minimum. The check valve is readily accessible for inspection by removing a hand-hole, and its failure is not probable. If the stoppage remains unnoticed for some time, it will overflow at the lowest fixture, if there is one in the cellar, and if not, probably it will overflow at the fresh-air inlet outside, if there is one.

If the pipes or traps become obstructed, they are all readily accessible without damage to partitions or floors.

I recall an instance where a party built a ten-inch main drain for a small house which would have been amply served by one of four inches in diameter. An untrapped pipe was left open at the basement floor, so that water might not accumulate in the basement. The wisdom of this procedure became apparent later when the house was completed, and it became evident that the main drain and the cold air duct supplying the furnace had been combined. A pipe four inches in diameter is too small for this purpose. The system outlined in Fig. 1 makes no pretensions to a "general purpose" utility.

If roof water is admitted directly to the sewers, the rain-water leader should connect with the main soil pipe directly above the main trap. No waste or soil pipe should be connected with the rain-water leader. In a great many cases it will be advisable not to discharge the roof water into the sewers, particularly in the case of isolated dwellings where a portion of it is retained by cisterns,

and where lawns are of considerable extent. In the case of more compactly built city buildings, it will often be best to allow the roof water to be discharged into the street gutters, especially where these are properly arranged, and the descent is sufficient.

The following table of the behavior of house drains when running three-fourths full, was calculated by Robert Moore, C. E., of St. Louis, Mo. : —

TABLE OF DIAMETERS OF HOUSE DRAINS.

With various grades, and for lots of different sizes, capable of discharging two inches of rain per hour, when running three-fourths full.

Calculated by Robert Moore, C. E., St. Louis, Mo.

SIZE OF LOT IN FEET.	FALL PER 100.						
	1.0	1.5	2.0	2.5	3.0	4.0	5.0
	DIAMETERS IN INCHES.						
20 x 150	3½	3⅛	3	2⅞	2¾	2⅝	2½
25 x 150	3¾	3½	3⅛	3⅛	3	2⅞	2¾
30 x 150	4	3¾	3½	3⅜	3¼	3	3
35 x 150	4¼	4	3¾	3⅝	3½	3⅛	3⅛
40 x 150	4½	4¼	3⅞	3¾	3⅝	3½	3¼
45 x 150	4¾	4⅜	4⅛	4	3⅞	3⅝	3½
50 x 150	5	4½	4¼	4⅛	4	3¾	3⅝
60 x 150	5⅜	4⅞	4⅝	4⅜	4¼	4	3⅞
70 x 150	5⅝	5¼	4⅞	4¾	4⅝	4¼	4⅛
80 x 150	6	5½	5¼	5	4⅞	4½	4⅜
90 x 150	6¼	5¾	5½	5¼	5	4¾	4⅝
100 x 150	6½	6	5¾	5½	5¼	5	4¾

By an inspection of the table, we see that a four-inch main drain is ample for any ordinary condition of service, even if roof water be admitted, the discharge of house sewage proper being only a very small percentage of the total volume. A smaller size than four inches is not to be recommended, however, for the reason that although it may be ample so far as estimated carrying capacity is concerned, it is more liable to obstruction. Under some circumstances, it may be advisable to increase the size of the main drain to five or even six inches' diameter ; this limit should not be exceeded, however. If one drain of this size is not ample, it is better to increase the number.

GEO. S. PIERSON.

President. — " I suppose that this contemplates an abundant supply of water, and pressure sufficient to cause all these sediments to disappear ; but I think for a common place or farmer's house, such as we generally find throughout the State of Michigan, there would be no greater convenience than to be able to take

away the kitchen slops without injury to the room and without the necessity of going out-of-doors."

Mr. Foster. — "The trouble with the kitchen slops and all that kind of stuff is that you can have good tiles and drains, etc., but they will get stopped up every time. I have tried a great many plans, but I think I have never been fortunate enough to find anything to displace the old 'slop pail' successfully."

Mr. Appleton. — "I think the best way is to take it out in a pail, and throw it out on the ground, scattering it over a considerable area, not throwing it into heaps."

Mr. Watkins. — "I have no system of house sewerage on my place, but I have a pail, and when it gets full, I carry it to the garden gate and throw it onto the garden, and every rain that comes washes it over the ground, so that there is never any bad odor arising from it."

Mr. Foster. — "In the city of Nottingham, Eng., they pump it up to the top of a hill, where it is distributed all over the adjacent country; and I can just tell you the crops they raise on those grounds would surprise you, the system keeping it enriched continually."

Mr. Appleton. — "And I would just say that is a pretty good paying thing, as it is not so expensive as one would naturally think it to be."

Mr. Wells. — "In small sewers, where the obstruction is caused mostly by the grease sticking to the pipes, I find that by pouring a little ammonia into the pipe occasionally, it will keep it clean."

Prof. Greene. — "If you will stir up a half pail of ashes with some water, and let it stand awhile until there is some strong lye, and pour that into your pipe, you will find it will clean it out pretty effectually."

Prof. Cooley. — "We have made a practice of spreading our coal ashes over our slops after being thrown into the back yard, and I have never noticed any odor from them."

APPLICATION OF PHOTOGRAPHY TO SURVEYING AND ENGINEERING PURPOSES.

To the President and Members of the Michigan Engineering Society :—

The recent progress in photography has made it an indispensable aid in nearly all of the arts and sciences. In engineering and surveying, it should receive attention as one of the most important means of improved practice in field work, until the camera is as familiar to the profession as the compass and transit.

But a few years ago the practice of photography in the field was limited to exceptional conditions, on account of the cumbersome outfit required, and the tedious processes involved in the

preparation, exposing, and developing of the wet plates used, on the spot where the observations were made. The skill of the professional photographer was, in fact, required to obtain satisfactory results.

These difficulties disappeared with the invention of the modern dry plates, which can now be procured at reasonable prices; and the best results can be secured with the exercise of ordinary skill, while the records obtained in the field can be kept indefinitely before developing, which may be done at home, in the evening, or during any convenient interval of leisure. The lenses used in the portrait galleries are unsuited for such work, as they give a distorted image that does not permit a quantitative comparison of the different parts of the field of view.

Aside from the camera and lenses which are needed for accurate work, but little apparatus is required, and that simple and inexpensive.

So far as the wants of the engineer or surveyor are concerned, the art of photography can now be learned in a few days' practice, if reasonable attention is given to a few simple details of manipulation.

Dry plates are now made so sensitive that good results may be obtained with even a moderate amount of light. Interiors and foundations may now be photographed at night by means of the magnesium light, as readily as in the most favored localities in broad daylight; and it is even difficult to imagine conditions that would prevent the satisfactory application of the art.

There are many applications of photography that will be readily suggested to the practical engineer. Aside from the copying and enlarging or reducing of maps and plans, by means of bromide paper prints, or the blue print process with which you are all familiar, we will ask your attention to the relation of photography to field work. In engineering constructions and buildings, a record of every detail of the work, from foundation to completion, can readily be made. The value of such permanent record in checking estimates, or in the study of any special features of the work, can hardly be overestimated. It is important that the photographic record should be made by the engineer himself, so that the strict conformity to a scale may be clearly observed. Without further examples, the utility of photographic methods of recording the progress of constructing details, must be fully appreciated.

In surveying, it will at once be suggested that a photographic record of monuments with their surroundings, will be convenient for future reference, and in cases of disputed boundaries, may be valuable as evidence. The latest applications of photography in topographical surveying are, however, of the greatest interest, as the new method of field work with the camera has the advantage of making a perfect record of every detail of the field surveyed,

while it furnishes the required data for a map on a horizontal plan, with an exact representation of every elevation and depression.

The mathematical and mechanical principles involved in photographic surveying were discussed by Col. Laussedat, of the French Engineers, as early as 1858, and they were soon afterwards applied under the disadvantages of the old wet plate process with remarkable success. In 1864, M. Javary made a photographic survey of Grenoble and suburbs. It agreed closely with the regular survey made by the engineer in charge of roads and bridges, the differences in level nowhere exceeding 19 inches.

Meydenbauer, in Germany, about the same date, "made a photographic survey of Fribourg and suburbs, plotting to a scale of $\frac{1}{1000}$ with ten-foot contours. The field work required two days; there were six stations and twenty-one plates; the plotting required eighteen days, and the resulting map was accurate in every respect. In 1874, M. Javary made in one day a photographic reconnaissance extending fourteen miles, and embracing the features for a distance of from one to two miles on each side of the route. And on another occasion he executed in fourteen hours the field work and plotting of a complete and exact map, including the leveling of a zone three-fourths of a mile in breadth; and this in rainy weather, and with wet plates."

Experiments made in 1878–80 brought the gelatine-bromide emulsion plates into notice, and since that time the process has been perfected and brought into general use. These dry plates are exceedingly rapid, and the simple manipulations required in their use leaves nothing to be desired in their applications to photographic surveying. In 1887, Lieut. Reed, of West Point, "made, with dry plates, a photographic survey of a tract containing about twenty-seven square miles; three principal and two auxiliary stations were used from each of which four or five views were taken. The field work occupied ten hours; and with a little more previous experience, the plotting, including the leveling, could have been readily performed in two or three days. For the leveling, about 100 points were determined from the views, and most of these points, in plan, construction, and leveling, checked exactly." According to Col. A. C. M. Pennington, U. S. A., in surveys made by this method in Savoy, "one survey of eighteen days' field work sufficed for 30,000 acres, contour lines being mapped five meters apart, giving five months' office work. In another case 110 proofs were taken for 20,000 acres, the field work consuming but fifteen days."

The advantages of this method of surveying are obvious. While the work is rapidly performed, there is a complete record of every detail of the field in both plan and elevation, so that accuracy is secured, under a multiplicity of checks against possible error.

The leading principles involved in this method of surveying may be briefly stated as follows : A landscape photograph, if made with a rectilinear lens, is a true perspective, in which right lines are shown as right lines, and curves as curves, each in due and fixed proportion to the original.

When the picture is taken, the camera must be carefully leveled in two directions, and a vertical plane through the optical center of the lens may be taken as a base line from which the angular distance of any point may be measured in a horizontal direction.

A horizontal plane in like manner projected through the optical center of the lens may be taken as a horizon from which the angular distance of each elevation and depression may be determined.

The key to these angular distances, either horizontal or vertical, is the equivalent focal distance of the lens combination, which must be carefully determined, and taken as radius in measuring the angles, by a protractor or a table of natural tangents.

It has been recommended in actual field work to measure a base line, from each end of which the entire field to be surveyed can be seen. From the ends of this line the bearing of several points in the field that can be identified on the photograph, may be taken with the compass, and this will serve as a skeleton plan when placed on paper, to aid in the plotting.

Two or more views should be taken with the camera from each end of the line, as it is necessary that each point of the field should appear on at least two plates. In plotting, the ordinary method of intersections is applied in fixing points on the plan, very much as in plane table surveying.

It is unnecessary to go into details in regard to field work and plotting, as these will be fully described in the works you will need to consult in applying the method in practice.*

Special forms of the camera have been devised for photographic surveying, but on the whole, the common camera will probably be the most satisfactory. It should be well made, with a rigid vertical front and back, so that the optical center of the lens will always coincide with the same point on the focusing screen. A "rising front" will be found convenient in adjusting the optical center of the lens to the wire that serves to record the horizon. The camera should revolve on a spindle fixed to the top of a tripod with leveling screws. A round disk of board, with graduated edges, fixed to the top of the tripod, will be found con-

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* References: "Photography Applied to Surveying," by Lieut. H. A. Reed, West Point, John Wiley & Sons, 15 Astor Place. New York. 4to; cloth, $2.50. This is probably the best and most comprehensive work on the subject.

"Topographical Drawing and Sketching," including applications in photography. Same author and publishers. $3.50; new edition, $5.00.

An article by Lieut. Reed, on "Photography Applied to Surveying," and another by Col. A. C. M. Pennington, U. S. A., on "Photography Applied to Military Purposes," printed in "Anthony's International Annual." Paper, 50 cents; cloth, $1.00.

venient to indicate the angle from the base line at which the view is taken.

A fine horizontal wire should be placed in the plate-holder, in the plane of the optical center of the lens, so that it will be in contact, or nearly so, with the plate when exposed, and thus record the horizon from which elevations and depressions are measured. A fine vertical wire in the plane of the optical center of the lens, and similarly placed in relation to the plate, will also be of assistance in orienting the views on the map.

A detached level will serve in adjusting the camera, which must always be leveled in two directions when the views are taken. Accuracy in all of the adjustments, as in the case of other engineering instruments, is essential to exact work.

As to the size of the camera, no definite rule can be laid down, as much depends on the character of the work. The larger plates are of course more cumbersome, and they not only cost more, but are also more difficult to manipulate. On the other hand, they have the important advantage of giving the views on a larger scale, so that greater accuracy may be secured in measuring and plotting.

Cameras for 5 x 8, 8 x 10, or 10 x 12-inch plates may be used, but the first mentioned is too small for any but limited areas. Taking everything into consideration, my impression is that 8 x 10 plates will be found most satisfactory for ordinary field work, and the camera for this size of plates need not be so heavy as to be objectionable on that account.

Only the best lenses should be used, and these must be of the rectilinear type. The ordinary portrait and landscape lenses give a distorted image that is not noticed in a portrait, but which entirely unfits them for architectural work or field surveying. It will be poor economy to buy a second-class lens, even if it is rectilinear, as it will fail to give the best results under unfavorable conditions of light. The lens must of course be adapted to the camera and the size of plate used, and as a general rule, its equivalent focal distance should somewhat exceed the longest diameter of the plate.

A lens of shorter focus, or a wide angle rectilinear lens, may be needed in circumscribed localities, where the long focus lens, best adapted to field work, cannot be used.

The equivalent focal distance of each lens should be accurately determined, as this is an essential factor in plotting from the negative.

There are many brands of dry plates now in market, and there is but little choice among the leading makers, as Stanley, Carbutt, Seed, etc. It will, however, be best to use but one kind, as each brand has its peculiarities in regard to development and exposure, and when one becomes thoroughly acquainted with the behavior of his plates under different conditions, he can obtain the best

results from them, when he might fail with a new brand that needed slightly different treatment.

Of the many developers now in use, the new hydroquinone will undoubtedly prove the best for all purposes, and it can now be obtained at a price that makes it the cheapest, as well as the best.

With a little experience, many applications of the art will suggest themselves. For example, a true meridian may be readily made with the camera. On a bright, star-light night, the camera may be carefully leveled and pointed approximately north, and a rapid plate may be exposed for several hours. The circumpolar stars will describe arcs on the plate, and the landscape beneath will also be copied. When the centers of the arcs are graphically determined, and radiuses drawn from them, the radius that is vertical will be on the true meridian, and it may be produced to indicate the required point on the landscape.

For photographing foundations or interiors, or copying at night, a magnesium flash light may be used with rapid plates.

Dr. Manly Miles.

DESIGN FOR PIER ON SOFT GROUND.

There are nearly 14,000 linear feet of timber pier at the St. Mary's Falls Canal. About one-third of the pier was built in place when the water was out of the canal, and the remainder was built in the form of cribs, and then sunk in place. Four spuds, one at each corner of a crib, being used to keep it in alignment, and the top nearly level, a continuous superstructure four feet high was built on the cribs.

No trouble was had in regard to a solid foundation, as the greater portion of the piers rests upon sandstone, bedrock, or hardpan, the principal exception being a section of the pier 200 or 300 feet long a short distance above the lock. After the excavation had been made for the pier side, there still remained a pocket of quicksand from two to seven feet deep on the sandstone rock, over which a line of continuous pier was built in place in March, 1881.

The method adopted was simply that of placing a platform of two-inch planks, six feet long, transversely under the front and back walls of the pier, and in order to allow for settlement, the planks were placed about four inches above grade. At present it is from one to three inches lower, but its alignment is as good as that of the adjoining piers. Last year the construction of the pier in front of Fort Brady military reservation having been determined upon, plans and specifications were prepared.

A shoal extended about 150 feet in front of the line adopted as the face of the pier. On the pier site the depth of water varied from two to twenty-nine feet. The material of the shoal was composed of silt, quicksand, and stones, and over 32,000 cubic yards were removed to a depth of twenty-one feet by dredging.

The location is such that there will be no heavy seas to withstand, so that in order to provide a proper foundation for securing stability and permanence of the cribs, it was only necessary to consider the pressure against it as a retaining wall, and the blows it might receive from passing vessels. It is possible that the pier and the area back of it may be used for a stone-yard during the construction of the proposed new lock.

The general plan of the crib is a modification of those forming the breakwater at Chicago and other Lake Michigan harbors. The principal changes are in the method of framing the ties, and in arranging the bottom course so that the side walls are directly over the bearing piles, thus making a somewhat stronger form of crib.

The cribs as designed are fifty-six feet long, twenty feet high, and twenty feet wide, except the bottom course, which is twenty-two feet wide. The timbers for the two upper courses of the cribs and the four courses of superstructure are to be of white pine, and that for the rest of the crib will be of hemlock. Each crib rests on fifteen bearing piles. To insure a true bearing on the piles, the bottom is made of three horizontal surfaces, each three feet wide, extending the full length of the crib, and corresponding in position to the rows of piles.

The cribs are built with tight sides. The cross walls are eight and one-half feet apart, each alternate one being solid, and the others with a foot of open space between the ties. Half way between the cross walls are grillage timbers at top and bottom. The timbers are twelve inches square, and carefully framed and firmly bolted together. The open bottom of the cribs allows the stone filling to pass through and form a solid base for the cribs to rest upon; and additional stability is given by triangular-shaped pockets in the end compartments; the apex of the triangle being down and next to the end walls.

Stones will also be placed in front of the pier to a hight of one foot above the top of the piles.

The contractor for excavating the lock pit will be required to fill the area between the pier and the shore line up to the level of the top of the pier. For a distance of twenty-five feet back of the pier, the filling must be of stone. The bill of materials for one crib is as follows: —

WHITE PINE. — IN SUPERSTRUCTURE AND UPPER TWO COURSES OF SUBSTRUCTURE.

1	piece	timber,	1 x 1 x	34	feet	34 cu. ft.
10	"	"	"	32	"	320 "
3	"	"	"	30	"	90 "
2	"	"	"	26	"	52 "
15	"	"	"	24	"	360 "
1	"	"	"	22	"	22 "
35	"	"	"	20	"	700 "
16	"	"	"	16	"	256 "
2	"	"	"	14	"	28 "
	Total					1,862 "

HEMLOCK. — IN SUBSTRUCTURE.

4	pieces	timber,	1 x 1 x	34	feet	136 cu. ft.
21	"	"	"	32	"	672 "
10	"	"	"	30	"	300 "
10	"	"	"	26	"	260 "
30	"	"	"	24	"	720 "
17	"	"	"	22	"	374 "
64	"	"	"	20	"	1,280 "
28	"	"	"	18	"	504 "
30	"	"	"	16	"	480 "
8	"	"	"	14	"	112 "
	Total					4,838 "

IRON.

557	drift bolts, 1″ ○ x 34″, wt. $7\frac{52}{100}$ lbs.	4,189 lbs.
39	" " 1″ ○ x 22″, " $5\frac{16}{100}$ "	201 "
28	screw and washer bolts $1\frac{1}{8}$″ ○ x 39″	368 "
7	" " " " $1\frac{1}{8}$″ ○ x 27″	69 "
	Total	4,827 "

15 piles, 32 to 45 feet in length.

The specifications are as follows : —

Description of Work. — The work to be done under these specifications comprises the construction of about 1,460 linear feet of pier. For this purpose the contractor will be required to furnish about 34,000 cubic feet (more or less) of white pine timber, and 96,000 cubic feet (more or less) of hemlock timber, 390 piles (more or less), and 89,000 pounds (more or less) of bolts; also to drive and saw off to grade 390 piles (more or less), to frame and place in the pier about 175,000 cubic feet (more or less) of pine and hemlock, and to fill the pier with about 22,000 cubic yards (more or less) of stone.

Locality. — The pier is to be placed in the St. Mary's River, in front of Fort Brady, Mich. A dredge, cut in which there is about twenty-one feet of water, has been made for the pier site.

Construction. — The pier will consist of wooden cribs built separately, then placed on a pile foundation, and filled with stone; next, a continuous superstructure will be built over the whole length of the pier; and, finally, the pier will be filled to the top with stone. Drawings illustrating the location and construction of the pier may be seen at the U. S. Engineer office at Detroit or Sault Ste. Marie.

The piles must be in the places indicated in the drawings, and they must be driven until a hammer weighing 2,000 pounds and falling fifteen feet will not drive the pile over one-half inch. After they have been driven, they must be sawed off so that their tops will be in a horizontal plane seventy-eight and one-half feet above canal datum (which corresponds to a depth of water of twenty feet). The top of each pile after being sawed off must be within one foot of the place indicated in the drawings. If any settling occurs after the cribs have been placed on the piles, leveling pieces, cut and framed to dimensions furnished by the United States agent in charge, must be added before the superstructure is built.

The ends, and the length of the two cribs at the northwest angle, may be varied. Special drawings will be furnished for these cribs and their superstructure.

Framing and Bolting. — The manner of framing and bolting, the position of ties, etc., must be as shown in the drawings (except that at the option of the United States, the upper six courses of the pier may be varied so as to give a batter of six inches). The workmanship of the framing and bolting of all parts must be as good as the best work of the existing piers of St. Mary's Falls Canal.

The diameter of the holes for the drift bolts must be one-eighth of an inch less than the diameter of the bolts, and the holes must be bored the whole distance that the bolts are to be driven.

Placing Cribs. — Each crib must be so placed on the piles that no point in its face shall be more than two inches out of alignment, and that the space between the ends of the cribs shall not be greater than one foot.

Filling. — The cribs and superstructure must be filled to the top with closely-packed stones.

Measurements. — The timber, piles, and bolts furnished by the contractor will be measured and estimated on delivery. The framing will be estimated by the cubic foot as measured after being framed and bolted in the pier. The stone filling will be estimated by the cubic yard after it is deposited in the pier.

Order of Work. — The order in which the work shall be prosecuted will be determined by the agent of the United States, whose instructions in all matters relating to the work must be conformed to by the contractor and his employees.

Time. — The piles must be driven (through the ice) before the 15th of April, 1889. The remaining work must be begun before

June 1, 1889, and completed before Nov. 1, 1889. From the beginning, the monthly rate of progress shall be, at least, equal to the average monthly rate required to complete the work within the specified time.

General Requirements. — Any timber, iron, or material of any kind, unnecessarily wasted by the contractor, will be charged to him, and deducted from his next succeeding estimate. Any stone or other material dropped into the canal or about the pier, by the contractor, must be removed by him without cost to the United States. No extra work of any kind will be paid for, unless specially ordered in writing. All drawings cited in explanation of these specifications are considered to form a part thereof.

Timber. — The white pine timber must be sawed accurately, free from splits, shake, rot, blackknots, wane, or other imperfections.

Piles. — The piles must be of hemlock, or other equally suitable timber; they must be straight and sound, and at least ten inches in diameter at the smaller end.

Iron Bolts. — The drift bolts are to be made from an approved quality of round iron, one inch in diameter, blunt pointed, and with round heads one and one-half inches in diameter. The screw and washer bolts are to be of similar round iron one and one-eighth inches in diameter. (A drawing will be furnished the contractor, showing the form of all the bolts.)

Offers. — Bidders must state the price per unit for the several classes of materials and work separately, but the aggregate, determined from the pieces and the approximated quantities, *will* be considered as one bid.

Payments. — Payment will be made monthly, reserving ten per cent from each payment until the completion of the contract.

There were eleven bids received; the lowest and highest being as follows: —

	White pine timber.	Framing white pine tim.	Hemlock timber.	Framing hemlock timber.	Furnishing piles.	Driving piles.	Drift bolts.	Stone filling.
	cu. ft.	cu. ft.	cu. ft.	cu. ft.	each.	each.	per lb.	cu. yd.
Lowest Bid	.24c.	.07	.13$\frac{1}{5}$	.07	$3.00	$4.00	.03c.	.48
Highest Bid	.30	.05$\frac{1}{2}$	.20	.06$\frac{1}{2}$	4.50	4.00	.07	1.50

Rate per linear foot of pier, $39.55, and $64.38 respectively.

Joseph Ripley.

MEASUREMENT OF A PRIMARY BASE.

In 1841 was begun what has since turned out an immense, complete, and most satisfactory work; namely, the survey of the great chain of inland lakes of North America, by the United States Government. It was carried on for forty years, the final charts not being out until 1881. The work was under the charge of the War Department, the immediate supervision being, at first almost exclusively, in the hands of Corps engineer officers, but later, as the scope of the work enlarged, and more engineers were necessary than could be spared from the Corps for this purpose, civilian assistants were added. Many of these latter were with the survey for years, and to some of them is due especial praise for the methods and suggestions in carrying on the work, in particular, the wonderfully careful result in Base Line work, shown in the Reports of E. S. Wheeler, who now, by the way, has charge of the Government work at the "Soo," under General Poe.

Previous to 1852, when for the first time our Government published three charts of parts of Lake Erie, there was absolutely nothing in the way of printed help for American Sailing Masters; for although even before this time, Bayfield, of the Royal British Navy, had done a great deal of really fine work in data for accurate charts, considering the rough methods and rapid reconnaissances that he in person must have made to cover the ground and water that he did, and in the time he did, these were not allowed out of the hands of the British Admirality, and our brave navigators of even up to a few decades back, knew best where a sunken rock was when it had punched a hole in their wooden bottoms.

The survey was started under a Government appropriation of $15,000, and at a time when a vessel leaving Chicago found no shelter until reaching the Manitou or Beaver Islands, and after passing the Straits of Mackinaw and Presque Isle, no harbor, until considered safe in St. Clair River. Even then she had to pass the dangerous fishing "Flats" before she reached our goodly city of Detroit.

With one exception (1847), Congress made yearly appropriations of sums varying from $15,000 the first year, to $175,000 each year from 1871–74. In the aggregate, for the forty years, and until the survey was completed, the appropriations amounted to $2,927,000. That this sum was in the main honestly and carefully spent, can be seen in the published charts, for they are as full and as complete as can be desired, and on them one can measure 6,000 miles of shore line. Thus for less than $500 per mile was the great survey made, and at an average rate of 150 miles per year. This is an odd way of figuring up such work, but still it is pertinent.

From the start, a general Geodetic Survey of the entire chain of lakes was contemplated, but owing to the meagerness of the ap-

propriations during the earlier part of the work, the actual operations were confined to localities where improvements were called for, or where navigation was specially difficult. Thus the small moneys were expended for preliminary surveys at these particular localities because of the pressing need of improvements, and the purchase of larger and finer instruments necessary for the more extensive and exact work was deferred for many years. These instruments, finally obtained mainly through the efforts of Gen. C. B. Comstock (who had charge of the survey from the spring of 1870 until its completion in 1881), were as fine as the world could produce. The Bache Wurdeman Base Line Apparatus, however, which I wish particularly to describe, and to which is due the exactness of the work, even to the determination of questions as regards the precise form of our world, was purchased as early as 1852, when Capt. J. N. Macomb was in charge.

It was constructed by Mr. Wm. Wurdeman, of Washington, under the direction of Capt. Thos. J. Lee, of the Topographical Corps, and was in all essential particulars similar to that made the previous year for the coast survey, but modified for the purpose of being lighter, smaller, and more delicate.

It is a contact apparatus, the measurement being made with two tubes, each consisting of an inclosed tin case containing two bars, one of iron and one of brass, firmly joined together at one end, and carrying at the other a compensating lever, so constructed that the tube shall have nearly the same length at all temperatures. The bars are each 168 inches long, the iron, 1.40 inches high and .27 inches wide, is immediately over and three tenths inches distant from the brass one, which is 1.10 inches high, and .37 inches wide. To the front end of the brass bar is hinged a vertical compensating lever, having on its rear side a knife edge which is pressed by a spring against a steel plate on the front end of the iron bar, while higher up another knife edge on the front face of the lever has constantly pressed against it a sliding rod, whose forward end, armed with an agate plane, projects from the front of the tin case, and forms one measuring end of the tube. The object of this lever, made as it is with the distances of the knife edges from each other, theoretically determined to correspond with the expansion of the two different metals, is to make the distance between the end points of the tubes during changing temperatures, constant, so long as the two bars have the same temperature. At the rear end of the tube, a vertical arc for measuring inclination is fixed to the upper bar, and is read by a vernier with a level on its arm, called the sector level, the horizontal axis of the vernier being perpendicular to the plane of the bars. The vernier arm carries a small cylindrical surface, the axis of which coincides when in adjustment with that of the vernier, at the instant the bubble of a small contact level moved by the same arm bearing the cylindrical surface, plays. Against this surface abuts

a brass rod, armed at its outer or rear end with an agate knife edge, and, projecting through, forms the rear measuring end of the tube. In guides, this rod has an end motion only, and when the tube is not in contact with its mate, is forced out by the counter balance on forward end of contact level. In measurement, the base line, which for primary triangulation is chosen on ground as near level as possible, and from four to six miles long, is carefully marked by stakes, and these stakes by scratches obtained by a theodolite placed in the vertical plane passing through the ends of the base line. The first tube is placed in line (by means of two theodolites) on carrying trestles, which in turn rest on iron pins, driven into the ground. The rear trestle has three legs, and is provided with a tri-rectangular head motion, while the forward one has only two legs, with head arranged for only a vertical and cross motion. By one of these slow motions on the rear trestle (the longitudinal), the tube is brought into place, so that the rear agate knife edge is, when forced in until the contact bubble plays, exactly over the minute marking on the metal button, firmly leaded into the base line end stone. This is done by the help of a theodolite placed at right angles to the base line. The second tube is now brought into place, the rear end by the various motions of the trestle head made ready for contact, and the forward end adjusted in line by a theodolite ahead. Contact is made by the longitudinal slow motion, the rear knife edge of the second tube being forced against the rigid plain agate in the front end of the first tube, until the contact level plays. Then the contact level, the sector level, the sector arc, and three very delicate thermometers inside of the ends and center of the tube, are read by two independent observers. Contact is then broken, the rear or first tube with its tent being brought back away from the second, and carried around and again aligned in front of it, and the work continued. To facilitate this, an extra set of trestles are used, to provide for there always being a set ahead in which to place the next tube. The iron pins on which the trestles stand are properly driven and leveled by means of trial bars corresponding to about the positions the trestles will have to take when holding the tube.

In order that no direct radiation of the sun may affect the tubes, portable frames, covered with canvas, and large enough for the observers to work under, are at all times carried over each tube. When, at night for instance, it becomes necessary to stop work, a theodolite is set up about ten feet from the forward end of the forward tube, and another approximately in a vertical plane through the end of its agate, at right angles to the line. By means of these theodolites, a mark is made directly under the agate, on the head of a copper tack in a stout peg, the top of which is driven below the surface of the ground. The stability of this mark during the cessation of work is checked by other similar marks, placed in a line perpendicular to the base line. The record is kept in duplicate by

two recorders, also all readings, accompanied by observations of the state of the weather, cloudiness, dampness, etc.

In an apparatus like the above described, composed of so many parts, and liable to change length at each of the places of contact, frequent comparisons with a standard are necessary. The standard used was a fifteen-foot brass bar, the temperature being fixed by packing it in ice which was constantly renewed. To determine what the length of the tubes was during the measurement, the comparisons were made under tents, and under circumstances as nearly the same as those of measurement as possible, and continued from 8 A. M. to 6 P. M., so as to include the same diurnal fluctuations of temperature as took place during measurement.

The method of comparison was as follows: —

Two contact level comparators reading to one hundred thousandth of an inch, were mounted on heavy stone piers, a little more than fifteen feet apart. The masonry supports of these piers rested on rock, and the piers were boxed nearly to their tops, to protect them from unequal changes of temperature. A tube resting on its trestles was placed between the comparators, the standard bar packed in ice was placed on top of the tube, and carefully aligned, and then by motions of the trestles, one or the other was brought between the comparators, contact made, and the comparators read, as well as the thermometers in the tubes. In reducing, the thermometers were corrected for their errors, and the readings on the standard bar and tubes plotted as ordinates with times as abscisses. On inspecting the curves made by the plotting of comparisons of tubes with the bar in ice, when temperature was above 65°, slight depressions are seen in the tube curves, arising from the cooling effect of the ice during the five or ten minutes it was on the tube. In extreme cases, these depressions amounted to .00040 inches.

The values of the comparator screws being very carefully determined, the differences between the tube and bar curve give the corresponding differences in length, and hence the length of the tube from the computed length of the bar at the observed temperature. In computing a measured line, every tube length in the several thousand times each was used, had to have these several following corrections applied: —

1. For inclination of tube to horizontal plane.
2. For reading of contact level.
3. For error in sector level adjustment.
4. For error in cylindrical surface above referred to.

The first of these needs no explanations. The second arises from the fact that the tube is at its definite length when the bubble is at the middle of the contact level, and changes by very minute known quantities when the bubble is not exactly in the middle. The third arises from the fact that the sector level is not stable in adjustment. When found, it is assumed to be proportional to the number of tubes measured since the last adjustment. It gives

a correction both to the grade angle and to the tube length. The fourth arises from a slight defect in the cylindrical surface, by which the tube was slightly shorter at *O* inclination than at any other. The sum of these corrections applied to the sum of tube lengths as found for each day's measurement, gives the length of the base.

To form an idea of the accuracy of the measurement of a base line, a portion of the Kewenaw Base, ninety-four tube lengths (about 1,410 feet), was measured over seven times. Deductions from a table of residuals, giving the excesses of the separate measures over their mean, shows a probable error of one measurement to be in .030 inches, or about 1–560,000.

Now again, besides all the corrections above applied, there are a number of others to be looked into before the length of a line can really be said to be obtained. The alignment of tubes which one would think could not be out an appreciable amount, carefully done as it is with theodolites, showed after numerous trials in testing for a lateral deviation from a right line, that, in the Buffalo Base, for instance, it amounted to .024 inches. There is another error entering into every measurement of a tube length, arising from the pressure of contact between consecutive tubes. This pressure, when reduced to the lowest amount consistent with constantly overcoming the friction of the sliding rod, was still four ounces. A tube, for instance No. 2, when brought into line and forced back against No. 1 till the bubble played, followed No. 1 some. No. 1 was in turn brought back away from it, and it was forced farther back when No. 1 was again placed in front of it. The amount of this disturbance varied with the precision with which the movable parts of the trestle fitted into each other, and with the hight to which the tube is raised by the vertical motion of the trestles. The rerults, from a hundred determinations of the amount of this displacement when pressure was adjusted to about four ounces, gave a mean of .00034 inches when the trestle was at its maximum hight, and .00013 inches when the trestle was down.

In the Buffalo Base, when the hight of the trestles averaged seven inches, and the line contained 1,483 tubes, the correction amounted to .69 inches. The last correction is to reduce the length as measured, to that of mean ocean tide level at New York. The Buffalo Base, levels of which were taken to and from Lake Erie, distant six miles, by the writer, and with results which happened to differ in the two measurements by less than one-tenth inch, showed it to be 35.7 feet above mean lake level, and mean lake level being 573.6 feet above New York tide, gave the Base an altitude of 609.3feet, making the correction for tide level a reduction of 7.77 inches.

The Buffalo Base Line as measured, with all corrections applied. and with decimal places beyond hundredths stricken out, is given at 266,966.61 inches.

Triangulation, carried over from the Sandy Creek Base at the other end of Lake Ontario, and distant two hundred and ten miles (measured similarly, and a year before), only differs from the above result by 1.44 inches in the computed length of the base line, or a discrepancy of about one in one million.

Now the probable error of an observed angle of average weight in the system, was found to be about one-half a second, which carried through the triangulations, gave results of 65.3 in units of the seventh place of logarithms, as the probable error in the length as computed. Comparing this with the difference actually found between the measured and computed lengths, 1.44 inches, it is seen that the actual discrepancy is about one-third of the probable error derived from uncertainties in the values of the observed angles, and therefore the discrepancy in measurement of the Buffalo Base line is about one in three millions.

WALTER S. RUSSEL.

THE POWER OF WATER MOTORS.

WATER motors are in such common use in cities and towns having water-works, that any information bearing upon their efficiency and power will be of interest to the Society. Perhaps no form of prime mover is so over-rated as the water motor of the Backus and Tuerk types.

A test on a 30-inch Backus motor conducted by the writer last summer in the city of Ann Arbor, will illustrate this point. In the Backus Motor catalogue (see p. 25), the 30-inch Double Motor under a pressure from 75 lbs. to 150 lbs. per square inch, is rated at from 8 to 12 horse-power.

The pressure during the test was about 83 lbs., and the maximum power taken off by the brake was 2.14 H. P., as shown by the following table: —

TEST OF 30-INCH DOUBLE BACKUS MOTOR.

No. of Test.	Radius of brake arm.	Weight of end of arm.	Revolutions per minute.	Brake horse-power.	Remarks.
1.	5¼ ft.	3 lbs.	564	1.692	When radius = 5¼ ft.,
2.	"	4 "	484	1.736	B. H. P. = $\frac{\text{wt. x revs.}}{1000}$.
3.	"	5 "	428	2.14	
4.	"	6 "	352	2.112	

The total horse-power and efficiency are as follows: head = $\frac{83}{0.4323}$ = 192 feet; velocity = $\sqrt{64.4 \times 192}$ = 113.2 feet per second.

Area of $\frac{1}{2}$-inch nozzle = 0.1963 sq. ins.
" $\frac{7}{16}$ " " = 0.1503 "
Total " nozzles = 0.3466 " = 0.0024 sq. ft.
Volume flowing per second = 113.2 × 0.0024 = 0.2717 cu. ft.
0.2717 × 62.4 = 16.95 lbs. per second.
Coefficient of discharge = 0.8
Actual calculated discharge = 13.560 lbs. per second.
$\frac{192 \times 13.56}{550}$ = 4.73 total horse-power.
Maximum efficiency = $100\frac{2}{4.73}$ = 45.2%.

The pipe leading to the motor was large, and put in with easy bends, in all respects a good job. The power realized was without doubt the most to be had with the nozzles used, $\frac{1}{2}$ and $\frac{7}{16}$ inches. The speed of wheel for maximum power was about 428 revolutions per minute = 7.13 per second; and 7.13 × 2.5 × 3.1416 = 55.97 feet, or about one-half the velocity of the jet for the best speed of buckets.

It will be seen, therefore, that the claim of the makers of from 8 to 12 H. P. is scarcely realized; further, it will appear that it cannot be realized when the total power, neglecting the coefficient of discharge, is only $\frac{4.73}{0.8}$ = 5.9 H. P.

Although the Tuerk Motor is also over-rated, it is somewhat nearer the truth than the Backus, as will be shown by the following calculation: A No. 12 Tuerk Motor is about the same size as a 30-inch Backus, and is used with a single $\frac{5}{8}$-inch nozzle. For a pressure of 83 lbs. per square inch (see catalogue, p. 11), this motor should give about 5 horse-power at a speed of about 463 revolutions per minute.

Area of $\frac{5}{8}$ nozzle = 0.3068 square inches = 0.00213 square feet, and 213.2 × 0.00213 = 0.241 cubic feet per second. 0.241 × 62.4 = 15.04 lbs. per second. 0.8 × 15.04 = 12.032 lbs. per second, and $\frac{192 \times 12.032}{550}$ = 4.2 total horse-powers. If there were no losses, then $\frac{4.2}{.8}$ = 5.25 H. P., which is but $\frac{1}{4}$ H. P. above the power rated in the catalogue. The actual H. P. will be not far from 45 per cent × 4.2 = 1.89 H. P.

The efficiency of this class of motors rarely exceeds 50 per cent. The *American Engineer*, issue of April 11, 1885, gives results of experiments on a 30-inch Backus and a No. 11 Tuerk Motor, by Mr. A. J. Jones, Superintendent of the Brunswick (N. J.) water-works, from which the following is extracted:—

Backus.					Tuerk.			
Press.	Rev's.	H. P.	Efficiency.	Wt. of water usd.	Rev's.	H. P.	Efficiency.	Wt. of water usd.
			per cent.	lbs.			per cent.	lbs.
50 lbs.	295	0.394	48.33	232.8	363	.552	46.34	341.2
					305	.696	47.32	468.2
45 "	239	.318	46.	220.2	366	.548	48.02	363.1
					274	.26	49.09	168.7
40 "	287	.273	47.14	207.5	378	.36	46.87	274.9
					364	.554	45.74	433.2
35 "	223	.212	44.7	194.1	312	.302	47.05	258.1
					300	.454	44.85	416.5
30 "	208	.159	42.26	180.	340	.323	43.10	358.2

The power realized from these motors is very small in amount, and the efficiencies are nearly all above 45 per cent. The efficiency of the Backus appears higher with the maximum load for which the whole was tested, while that of the Tuerk is higher for some of the smaller loads.

The amount of water used for any one of these motors doing considerable work, is necessarily large. For example: The Backus double motor tested consumed 13.56 lbs. per second = 48,816 lbs. per hour = 5,858 gallons per hour approximately, or 2,735 gallons per H. P. per hour. For 8 H. P., about 21,880 gallons per hour would be required. It would therefore appear that except for very small powers, the water motor in its present form is not likely to be used to any great extent.

Water motors for considerable power, and known as the Hurdy Gurdy, are used on the Pacific slope in the mining districts under the enormous heads existing there under which turbines would soon wear out. With a special form of bucket, known as the Pelton, an efficiency of over 85 per cent is claimed to have been reached.

M. E. Cooley.

COVERING STEAM PIPES.

The benefits of covering steam pipes to prevent radiation, are strikingly illustrated by the following example: —

The Thompson Houston electric light plant in Ann Arbor has about 60 feet of 7-inch pipe connecting the boilers with the engines, and two large steam drums above the boilers. In March, 1887, the steam at the far end of this pipe was tested to determine the amount of entrained water, the pipes and drums at the time being uncovered. An average of nine experiments gave 31.01 per

cent of moisture. In June of the same year, after the pipes were covered with magnesia sectional coverings, the quality of the steam was again tested, the average of five experiments giving 3.61 per cent moisture. The tests were made by the same men, from the same connections, and in the same manner. The pipes and steam drums in March were subjected to a draught, which of course aided the condensation. Enough water passed into the cylinders to retard the engines, producing a disagreeable noise. In June, the weather was warmer, and the pipes and steam drums were well protected. The quality of steam at the boilers was tested in June, and showed about 3 per cent of moisture.

Assuming that 100 I. H. P. were being developed at the time, and that each horse-power required 30 lbs. steam per hour, we would need 3,000 lbs. steam. If the steam is assumed to have 25 per cent entrained water due to condensation in the pipes and connections, then 4,000 lbs. steam will need to be produced in the boilers, or 1,000 lbs. more than necessary. To produce this steam will require about 125 lbs. of good coal per hour, or 1,000 lbs. per day of 8 hours. One-half ton per day, at $3.00 per ton, for 300 days = $450, which at 6 per cent pays the interest on $7,500. The actual cost of the covering put on complete, probably did not exceed $150.

M. E. Cooley.

THE MICHIGAN CENTRAL TRANSFER STEAMER "ST. IGNACE."

The problem of making safe and sure winter connection between ports at different points on our great water-way, has always been difficult of solution. Bridges are not advisable, sometimes not possible, and of necessity transfer steamers and passenger ferries must be used. In comparison with paddle boats, propellers have proved themselves the better workers in ice, if there is plenty of water under them. The Michigan Central R. R Co.'s problem then was, Given plenty of water in the straits of Mackinaw, six miles wide, and plenty deep enough, to construct a transfer that shall be trustworthy in all weathers, and to which ice will be no obstruction. The solution was the "St. Ignace."

She was built in 1888 by the Detroit Dry Dock Co., after designs by Mr. F. E. Kirby, a member of this Society. His experience in planning, and the company's experience in building boats for this kind of work, have made her probably the most successful boat of her class ever built.

She has 201 feet length of keel, 232 feet over all. Extreme breadth, 52 feet; molded depth, 24 feet; capacity, 10 freight cars or 8 passenger cars; light draft, 15 feet; load draft, 17 feet; load

displacement, about 2,600 tons. The lines of her forward and after bodies are very much alike, and are finer than is common with boats of this class, fitting her to attain a speed of about 15 miles per hour. Owing to the rounded shape of her cross section, slush ice, the worst enemy of the flat bottomed boats, cannot stick to her bottom, and so retard her progress. The bottom is completely swept by the powerful currents from the propellers.

The hull is of remarkably strong construction, especially the bow, which has to resist the crushing force of great masses of ice. The frames are 24 inches deep on the keel, and 12 inches thick; spaced, 33 inches centers; planking, 6 inches thick. She is plated from the keel to a point above the water line. All above a point below the load water line, is $\frac{1}{4}$-inch steel. The remainder is $\frac{3}{16}$-inch steel. The stern and rudder guard are specially protected by plating three inches thick. It will be noticed that the lower deck beams, 10 inches square, come just at the level of the load water line, where the pressure of ice is greatest. They are spaced 33 inches centers the entire length of the boat, cut, of course, at the hatches. The drawing also shows the breast hooks, three at each end of the boat. They vary from 11 to 13 inches in thickness. Exceptional care was taken in framing the "dead-wood" at each end, making stem and stern almost as substantial as solid timbering. Between the frames and planking, let into the frames, is a system of diagonals of 5 inches by $\frac{5}{8}$ inches iron, bolted to the frames, and riveted together at the crossings, which gives great longitudinal stiffness to the boat.

The two tracks are parallel to the side lines of the deck, leaving room for the cabin between them. The cars are run on at the bow, which is only 20 feet wide, and the tracks cross on the table to simplify the curves on the boat. The swinging table is 50 feet long. The rails are laid on pine sleepers which rest on the upper deck beams, and a line of stanchions runs the length of the boat under the middle of each track, except at the boiler hatch. Here the beams are iron, with channel iron stanchions between the boilers.

The crew are quartered below decks in the after part of the boat. The cabin above decks is very complete in plan, differing in this from the ordinary transfer boats, because of the length of her route.

Kitchen and dining room, ladies' saloon, officers' quarters, smoking room, dressing rooms, etc., are provided and nicely furnished. Additional room is secured on the saloon deck by making it project over the lower cabin at the sides, still leaving plenty of room to work on deck around the cars.

She has two fore-and-aft vertical compound engines, the forward one being 26-inch and 48-inch cylinders by 40-inch stroke; after one 38½-inch and 53-inch cylinders by 48-inch stroke. The forward propeller is 10½ feet in diameter and 15½ feet pitch. It is so con-

structed that all its faces are driving faces, hence it is equally efficient whether its engine is working forward or reversed. The after wheel is 12 feet in diameter, and 15½ feet pitch. Both are well below the water line out of reach of the ice, the top of the forward one being nearly 6 feet, and of the after one 4 feet below the surface when she is loaded. The shafts are each about 70 feet long, including crank shafts.

The boilers are three in number, of steel, 11½ x 18 feet, working at 130 pounds' pressure. They are of the double-ended type, combustion chamber in the middle. There are four furnaces, aggregating 91 square feet of grate surface in each boiler, burning all together about 10,000 pounds of coal per hour. They occupy about 34 feet of length in the middle of the boat. They are connected to a single steam drum, from which the steam is distributed to the engines. The steam pipes are of copper, and exhaust pipes to condenser are of wrought iron.

A single condenser is used, located by the side of the after engine. The two air pumps, 24-inch diameter, and 16-inch stroke, work at the ends of a beam operated by special engines, so that either of the main engines may be stopped at will.

The coal bunkers are of 300 tons' capacity, between the boilers and engines. The coal hatches, 4 in number, are between the rails, so that the coal can be taken from hopper cars without handling.

The steamer is steered by a specially designed steering engine situated on the main deck, 27 feet below the pilot house floor. The valve is operated by a hand wheel in the pilot house. There is also a pair of large steering wheels connected directly with the drum on which the ¾-inch wire tiller ropes are wound, for use in case of accident to the engine. The rudder stock is 9 inches in diameter, and as the rudder is protected from the ice by a heavy wing of timber, there is scarcely any possibility of injury to that part of the apparatus. A 6,000 candle-power electric light, operated by a small dynamo in the after engine room, and capable of being turned in any direction by the pilot, is placed on the pilot house.

A valuable feature of the outfit not possessed certainly by any other boat on the lakes, and probably by no other American-built boat, consists of two iron tanks 6 feet square, extending the breadth of the boat on the main deck. They contain from 15 to 20 tons of water each, and act as anti-rolling tanks. When the boat rolls, the water runs to the lower end of the tank, and is just enough behind the roll to meet the boat as she rises, so that it is always found on the rising side of the boat. This principle, applied by Mr. Kirby to a small model, reduced the rolling more than 75 per cent.

There are four steam capstans on the deck for handling the lines quickly and effectively when the boat is at the dock. The engines are close up against the lower side of the beams, out of the way,

and nothing appears above deck but the capstan head, and the handle for opening the steam valve.

To prevent the heavy waves or the ice from coming over the bow, a heavy gate has been constructed, swinging on hinges set on top of the rail of the boat, which rises up to let the cars pass under.

Under the head of "outfit" might be noticed a portable dock which was sent with the boat. It fits either end of the boat well enough to be made water-tight by a loosely spun rope of oakum. In case of damage to a propeller, this dock can be put on, pumped out, and the damage attended to while she is at her wharf.

As the cars, especially long passenger cars, come very close to the cabin when she is loaded, it was thought advisable to provide against the consequences of a sudden lurch of the boat in heavy weather, by putting screw jacks under the corners of the cars to prevent rocking. They are put under all four corners of each car on a very rough passage, but need not be used much in summer.

By her performance, the "St. Ignace" has realized the hopes of her most sanguine friends. Her anti-rolling tanks have been thoroughly tested by using them with all depths of water in them. Full of water, they only increase the roll, bringing it near the danger limit in very rough weather; but used half full, or a little less, the effect is as great as was anticipated from the use of the model referred to. She rolls very slowly, with no quick recoil appreciable.

She has cut her way through field ice two feet thick without great difficulty or any injury to herself, and has not been hindered by ice clinging to her bottom, as before noted. The severest test of her power is applied when she crosses a "windrow" of ice. These windrows are piled up at the leeward edge of a field during a hard blow, and are sometimes twenty feet deep, and consist of loose ice and slush. She has never been stopped by one of them, and from the way she has behaved at these times, it is thought she will meet all the demands upon her in the future.

To come into her slip when it is full of ice, the after engine is worked full speed ahead, while the forward one is reversed. As the after one is twice as powerful as the other, she works slowly ahead, while the forward engine throws into the slip under the ice a powerful current of water that heaves it up and breaks it. Then with both engines full speed ahead, she forges into the slip, and the ice is further ground up and drawn out by the current under the boat.

With such complete success in view, it may be that some day we shall see a fleet of boats, headed by another of the "St. Ignace" type, making the trip from Chicago to Buffalo as regularly in winter as in summer, without a day's stoppage "icebound."

E. L. Mc Allaster.

LAKE SUPERIOR MINES.

To the President and Gentlemen of the Michigan Engineering Society: —

The country bordering the "great unsalted sea" of the North, is one of marvelous mineral resources. That portion of it known as the upper peninsula of Michigan, is an empire within itself. But the blue waters of the lake wash also the far-reaching shores of Wisconsin, Minnesota, and Canada. The stores of valuable mineral, already discovered in all of those sections, excite the wonder of the most casual observer. Indeed, they attract the attention of the whole world. The products of the mines of Lake Superior have found their way to the most distant markets, and, owing to their excellence and purity, are highly appreciated, and eagerly sought after.

During the season of 1888, the iron mines yielded 4,671,947 tons of ore. During the same period, the copper mines shipped 59,574,066 pounds of refined copper, equal to more than 29,000 tons.

Within the memory of many of my hearers, this country was called a howling wilderness — a land of ice and snow — not likely to attract settlers, or become the home of civilization. In 1840, in the United States Senate, the great Henry Clay ridiculed the idea of a ship canal at Sault Ste. Marie, and said that we might as well undertake to open a way to the moon.

When the General Government gave us the Upper Peninsula as a sop to allay our angry feelings in the little boundary dispute down by the Maumee, our people received the gift with a scoff and a sneer. But there was a divinity that shaped the contour of our great State better than all the engineers and surveyors of that day could have done it. It is a trite saying that "we do not always know what is best for us." Surveyors often run random lines, not knowing where they will come out. The random work of Uncle Sam in giving us the Upper Peninsula, *nolens volens*, has placed our Michigan at the forefront in the way of resources.

It is with this portion of our commonwealth — the Upper Peninsula — that I now have to do. Your honorable Secretary intimated that a chapter on the mines of Lake Superior would be acceptable at this time. I gladly assented to his proposal, but would venture to remind you that the subject is a broad one. In the brief time allowed by your rules, I can scarcely do more than outline the subject. I must needs invoke the aid of a 40-horse power air-compressor engine, such as is used at the mines, to help in condensation. Highly rarefied "wind," as I understand it, is not favored by this Society.

So I must skip over the topography and surface geology of the country, and bring you at once down to the mines. All specula-

tions as to the origin of the chief minerals, their abundance, and as to what future discovery may reveal, must be ignored.

The two principal fields, at the present time, are those of iron and copper. It is to the mines in these fields that I would call your attention. There are silver and gold mines of great promise, but those industries are as yet in their infancy. Other valuable minerals are known to exist, but their development lies in the future.

The iron fields are the most extensive. Actual discovery covers a large territory, but much is left to be revealed. Beginning far down the Menominee River, the iron belts sweep through the counties of Menominee, Iron, Marquette, Baraga, Ontonagon, and Agogebic, hundreds of miles, and, overleaping the western boundary of Michigan, pass into Wisconsin, and over into Minnesota on the north side of the Lake, — a grand sweep indeed. The arithmetic of man would fail in estimating the hidden wealth of this vast territory. The iron ore is of the best quality; there are several varieties. The Bessimer and Magnetic ore are the most valuable. The immense deposits of ore, found in individual mines, is wonderful. The hard facts in the case do away with fable. Bodies of pure ore, thousands of feet in length, a hundred feet in width, and of unknown depth, invite the miner's attention, and reward his toil.

The geological surveys under Dr. Houghton afforded a glimmering of the existence of iron in the Upper Peninsula, but it was reserved for Mr. Philo M. Everett, of Jackson, Mich., who organized the Jackson Mining Co., to discover, under the guidance of an old trapper and fisherman, a Frenchman named Louis Nolan, ridges of ore, at a place back of Carp River (now Marquette), near Teal Lake. Professor Shepard, of New Haven, Conn., when shown a specimen of the ore, declared it to be very fine, but thought it nearly worthless, as it was so far away. Numerous successful and very profitable mines of many years' standing attest the value of this discovery, and the two flourishing cities of Negaunee and Ishpeming bear witness to the richness of the ore beds around Teal Lake. If you wish to see industry, enterprise, skill, and prosperity exemplified, visit these thriving mining and pioneer centers.

At first, the shining black or slate-colored iron ore cropped out in long narrow ridges, from 20 to 100 feet above the general surface. The faces of the cliffs were denuded, often polished. They had *weathered* in many places, and masses of the pure ore had rolled down to the bottom. The first mining operations were simple enough, and consisted in quarrying the ore on the surface. But as the work went on, and mining went under ground, new and more scientific methods had to be adopted. Regular shafts were sunk, and underground drifts or galleries were planned. The aid of machinery was called in. Shaft and engine houses were built;

in short, the original quarry became, in time, a great mine, with all modern appliances in equipment and plant. A busy mining town, homes of the miners, operatives, and merchants, grew up close by. Tram car tracks checker the surface, and the locomotive, hauling long trains of ore cars, is busy in every direction. The earth is torn up on all sides; *here* a pile of waste material; *there* a pile of shining ore in the stock pile; and, in the midst, great yawning excavations, whence the iron has been removed, and which you must take care not to approach heedlessly.

The older mines are now down many hundred feet. Heavy hoisting machinery is used in bringing the ore to the surface. Then T-railways lead down into the mine. Tram roads are laid in the underground galleries. Long steel drills, run by compressed air, bore a 2½-inch hole 20 feet deep, speedily into the solid ore. A dynamite cartridge is dropped into it, and the explosion brings down great masses of a hundred tons or so. This is re-broken, loaded into cars, trammed by men to the skip shafts, hoisted to the surface, and dumped on the platform prepared for it. Here it is assorted, loaded on ten-ton cars, and hauled to the Great Lake or elsewhere. Mining for iron is a simpler matter than mining for copper. Still some of the iron mines are of such great width, and the containing rocks are so unstable, that much timber and engineering skill are called into requisition in placing it. Large pumps are necessary to free the mine of water. The mines are well ventilated, the air pure, with no dangerous gases threatening explosions. Care is exercised in the use of high explosives, only the most intelligent and trusty men being allowed to use them.

Great skill, great economy, a liberal use of modern inventions, are seen at these mines. The progress made in mining during the last quarter of a century exceeds all pre-conceived ideas or practice. It is such inventions and appliances that insure the success of mining to-day.

Most of the mining corporations of Lake Superior show great liberality toward their employees, and some of them show a humane spirit which is truly admirable. Churches, hospitals, schools, libraries, places of innocent amusement, comfortable cottages, etc., are provided for the people. I am happy to say that the squalor, poverty, misery, and turbulence that characterize many mining communities do not exist on Lake Superior; and I am inclined to believe that Lake Superior miners, as a class, are "superior" men.

But I can devote no more space to the iron mines. I already stand in fear of the President's bell, lest it ring me down.

We now come to the copper district, which occupies a distinct geological field north of the iron.

By reference to a map of Lake Superior, you will observe a prominent cape jutting far out into the lake. This is known as Keweenaw Point. By reason of the artificial canal, named the

Portage Lake and Lake Superior Ship Canal, this point is now actually an island. The copper-bearing rocks constitute the backbone of this remarkakle cape. The trap range, as this backbone is called, begins at the extreme northeast end of the Point, and runs in a southwesterly direction through Keweenaw, Houghton, and Ontonagon counties, a distance of about 150 miles. The width of the range varies from three to four miles, flanked by sandstone, metamorphic, and old red. It is composed of trappean rocks of different kinds. The whole range is tilted up from 32° to 45°. Originally the beds occupied a horizontal position, and were probably of sedimentary origin. At the advent of the white man, the whole surface was covered with a dense forest, the underbrush being very close. The elevation of the range is from 500 to 1,500 feet above the surface of the lake. Three classes of veins and lodes have been worked, — the true fissure vein, as at the Cliff mine; the contact vein, as at the Minnesota; the amygdaloid belt or lode, as at the Quincy; and the conglomerate lode, as at the Calumet and Hecla. These are characteristic. Fissure veins cross the range at right angles, having a northerly and southerly course, and dipping a few degrees to the east. These veins produce mass copper, as main out-put. The contact vein runs with the formation, and also produces mass copper. The amygdaloid and conglomerate belts or lodes, also run with the formation constituting a part of the solid mass, and while they yield considerable irregular mass copper, their main supply and dependence are found in what is called "stamp copper," that is to say, virgin or native copper in the shape of shot or flakes distributed throughout the matrix of the lode, requiring stamping and washing to fit it for the smelting works. I beg to remark that the Lake Superior copper is not an *ore*, like iron or the sulphuret of copper, but a virgin metal, like gold. Copper ore, it is true, is found at some points on the range, but its exploitation has never, thus far, been attended with success.

The existence of copper in that country was known to the aborigines and to the *voyageurs* and Jesuits. An English company, under Henry, in the last century, undertook mining in that region, but failed. The astute Ben. Franklin was informed on the subject. As one of the commissioners to settle the boundary line between the United States and British Possessions, he carelessly drew a red line through Lake Superior so as to include Isle Royale, which lies within eighteen miles of the Canadian shore, and which, he *guessed* was rich in copper. He was a Yankee, and guessed right.

But long before the Jesuit fathers, with indomitable courage, launched their canoes upon the limpid waters of the lake, an unknown people, named the Ancient Miners, had discovered the copper, and mined for it extensively, though crudely, all through the copper district, including Isle Royale. They were a brave, enterprising people certainly, and their extensive works excite the

wonder and admiration of the modern explorer. They mined with stone hammers and fire.

Dr. Houghton's researches from 1840–45 threw great light on the copper region, and fixed as a certainty the existence of copper in workable veins. The emigration to the new El Dorado rapidly followed his disclosures. Mining was begun, and has continued, under varying circumstances, until the present time. It is now a great and prosperous industry.

Exploring for copper was and is laborious work, owing to the dense forests and deep drift. The drift is anywhere from one to 100 feet deep; at only a few points are the rocks *in situ*, denuded. The discovery of veins and lodes, therefore, is preceded by much digging and trenching, uncertainty and cost.

Modern mining in the copper districts of Lake Superior affords an example of the highest skill, combined with liberal expenditure, indefatigable labor, and profitable results. The road to this high eminence has been long and weary, under losses and discouragements, leaving many wrecks by the way.

Having discovered a lode or vein of promise, we proceed to open a mine. The spot is in the heart of the forest. By ax and brand it must be cleared. Log huts for shelter are erected. Rude engine and shaft houses, carpenter and smith shops, are thrown together with little order. Roads are cut out to the nearest navigable water, in order that supplies and machinery may be brought in. At first the work is tentative. Until the lode has been proved valuable beyond reasonable doubt, expenditures are wisely limited; but the opening of the vein is pushed vigorously. The hunt for copper in quantity is the absorbing business.

But when, after practical experiment — actual work down in the solid crust — the miner feels assured that he has a good mine under his feet, he goes ahead boldly. The engineer lays out the surface ground carefully, locating the working shafts, engine houses, machine shops, rock houses, railways, and town site with care, having in view the future needs of a great mine. The wilderness rapidly disappears, and a bustling mining town, embracing within its limits churches, school-houses, hospitals, stores, miner's cottages, fine mansions, etc., springs up as if by magic. There are hotels without a bar; saloons are *tabooed* on the mine location.

Meantime, the work of sinking shafts, opening drifts, in short, the development of the mine, is pushed day and night. The mining engineer keeps this work well in hand. He establishes a permanent base line on the surface. From this base he carries his triangulations and measurements down the shafts to the underground city. He follows hard after the miner and plats the work on paper at every important step. His fixed points or benches underground are plugs secured in the solid rock. The light of a candle is his guide in the dark recesses of the mine. The working shafts are placed from 400 to 600 feet apart on the line of the lode.

They generally follow the pitch or inclination of the lode in their downward course. At the depth of 100 feet, the first grand level is reached. At this point horizontal drifts are started right and left from the shaft, on the line of the lode. The work in the shaft is ever downward; there is no pause until the second level is reached, and so on to the third and fourth, etc. Between the shafts, below the first level, sub-shafts are sunk to aid in work and ventilation; these are technically called *winzes*. Thus a plan of a well-opened mine resembles a map of a city. The shafts and drifts are the avenues and streets, while the winzes are alleys. The engineer's extended map of the mine, kept in his office, enables him to point out at any time the depth and length of the workings, the position of the pumps, man engine, tram-ways, stopes, rich and poor ground, and the very places where the miners are at work at a certain time.

The mine thus opened, the main work of producing copper begins. The squares in the underground city are mined out from between the walls of the lode. Be the lode five or fifty feet wide, the vein matter, carrying copper, is all blasted down, and hoisted to the surface. This work is called *stoping*. Great chambers are left after the rock is removed. The mine would close up, by the hanging walls' falling down upon the foot, if not prevented by artificial supports, called *stolls*. The heaviest timber to be found in the native forests, — pine and hemlock, — is used for this purpose. They are set up as thick as they can stand all along the drifts. An enormous amount is used monthly. The supply in the yards would cause a stranger to look around for a saw-mill, as a necessary adjunct. Much other timber, called *lagging*, is used under ground to cover the stolls, and for staging. The stolls are so placed that the tram-ways run under them, and the lagging thrown over the stolls prevents the mined rock from impeding the passages, and hurting the men. As the mine is worked out, the upper levels are great unused chasms, but all the timber is left standing. In time this timber becomes very dry. If set on fire, the burning is rapid and fierce, for the shafts are like great chimnies, with excellent draught. The great and disastrous fires which have occurred in the Calumet and Hecla mine within the last two years, afford an example of the danger always threatening a mine of this kind.

Tram roads are laid in each level, and cars pushed by men transport the rock to the hoisting shafts.

The shafts are elaborate and costly. They vary in dimensions, according to the use they are put to. They are solidly timbered and planked from top to bottom, with T-rail tracks laid in them. The track is a steep inclined plane. Cars carrying from four to six tons of rock move up and down with great velocity. These cars, or skips, are made of boiler iron of peculiar shape. Some of the mines are more than 4,000 feet deep. Heavy wire or

steel rope, winding around an immense drum moved by the great engine on the surface, is used in hoisting. The drum is thirty feet in diameter, with friction gear, and one man standing at a little wheel, manages it as easily as a toy. Ingenious indicators, placed before the man, tell him exactly where the car is at any time in the shaft. The skip car is carried thirty or forty feet above the surface of the ground, in the shaft house, where it dumps its load automatically, and immediately descends into the mine.

Surface cars receive the rock, and by means of an endless rope, they are whirled rapidly away to the distant rock house. No man is seen about the shaft house. The cars move automatically, dump themselves, and return to the shaft for another load. Signal bells, under ground and along the surface tram-ways, transmit orders.

The winding engines, moving four thirty-foot drams, are immense in size, but move very quietly, though powerfully.

The pumping-engine is a marvel in its way for power and in construction.

The man engine, used by the miners on their way in and out of the mine, is an ingenious contrivance. It consists of two parallel rods of wood, a foot square, placed about two feet apart in a separate shaft. Every ten feet, on each rod, a narrow platform is placed with an iron hand-railing. In moving, one rod goes down and the other up, with a ten-foot stroke. A miner steps onto one platform, and goes down ten feet. Then he steps across to the opposite platform (which has come up to meet him), and sinks gently down ten feet, and so on, till the bottom of the mine is reached. A hundred men may be on the rods at the same time. All are conveyed rapidly, without fatigue or confusion, to their destinations. There are ladder ways leading down into the mines, but they are not much used. Climbing them is very hard work.

The rock house above alluded to is a great building where the copper rock is dumped, assorted, re-broken, and prepared for the stamp mill. Large blocks of rock, tied together with copper, very tough, are dragged by a chain and steam-power under a great hammer moved also by steam. This hammer or punch is a long solid shaft, standing upright, with a steel pointed end. It drops upon the hard copper rock, and pierces and shatters it like glass.

The broken masses are then conveyed to different sized rock breakers, where they are crunched up into pieces suitable for the stamp mill. From the breakers, the rock falls into great bins; thence it is drawn into rock cars, and drawn by locomotives several miles to the stamps. At the stamp mills this rock is dumped into great bins located near the top of the mill. The rock runs down to the stamp (its motion regulated by one man), where it is crushed to fine sand under a blow of more than forty tons from the steam hammer. A stream of water, pumped up to the top of the building, runs constantly into the stamp mortar, and carries away the sand, slime, and copper to a series of washers moved by machinery.

The jigging movement of the washers causes the copper to settle onto the wire screens, while the water carries the sand and slime away to a place of deposit.

Immense pumping machinery is used. A large volume of water is, in some cases, elevated 100 feet, and distributed. Each stamp has a capacity of crushing from 100 to 150 tons of hard rock, during each twenty-four hours. The Calumet and Hecla mine has sixteen to twenty of these stamps, and can stamp at least 1,600 tons per day.

The limit of my article will not permit me to make more than this brief mention of the great stamp mills in the copper districts.

Most of the mines have fully equipped steam freight railroads of their own, which are kept constantly busy.

Large smelting works for reducing and putting the copper in shape for market, are appendages of the mines. There are likewise rolling mills of great capacity, wherein sheet copper, wire copper, etc., are made and shipped.

The old-fashioned way of mining with hand drills and black powder, is now obsolete. Power drills, run with compressed air, do the boring in the solid, copper-fastened rock. Dynamite cartridges do the rending and tearing very effectually. These improved methods have greatly reduced the cost of mining, and facilitated the work underground. Nay, they have been the salvation of many mines, during eras of low-priced copper. Each drill does the work of ten men, thus saving the cost of that many miners for each. Work is also done much more rapidly. For example, with powder and the hand drill, two levels only could be sunk in a year. With the power drill and dynamite, one level a month, or twelve in a year, can be sunk. The same proportion holds with drifting, stoping, and other kinds of work.

The diamond drill is much used for exploring purposes, either in sinking from the surface into the earth's crust, or in the mine.

The Calumet conglomerate charged with copper, is well defined and unmistakable. It lies inclosed between trappean rocks of entirely different structure and character. For these reasons, the miners have no difficulty in following the lode.

But in amygdaloid belts, the courses of copper are more irregular and uncertain. The lode proper is sometimes lost, or becomes mixed up with the *country*, or containing rocks. The copper has somehow disappeared. The diamond drill now comes in as an efficient agent. Horizontal holes, one inch in diameter, are bored from a selected level, right and left, and the lost lode is found. Perhaps entirely new and unexpected copper deposits are found to reward the explorer. The diamond drill penetrates twenty to thirty feet per day, at light expense. By the old-fashioned way of *cross-cutting*, six miners often spent a month or six weeks in reaching the same result.

Some bold and neat engineering feats have been achieved at the copper mines. At the Tamarack mine, we have a notable example. This company owned two forty-acre tracts of land, situated some 3,300 feet west of the Calumet lode. The Calumet lode was supposed, in its deeper reaches, to dip under this land. But the great problem to be solved was this: If it *does* dip thus far, does it carry copper as rich as that in the Calumet mine? does it carry copper at all? The Tamarack Co. boldly determined to solve the riddle. They sank, in about two years, and at great expense, a huge shaft, large enough for double skip tracks and the pump, over 2,300 feet perpendicularly through the barren trap rock of the country. They struck the Calumet conglomerate about where they expected to, and "*struck it rich.*" It is now the second best copper mine on Lake Superior. The Tamarack mine offers the only example of a perpendicular shaft in the stamp copper mines.

The rapidity with which the shaft was sunk, as compared with old-time mining, was truly marvelous. Boldness, skill, energy, capital, dynamite, and power drills were the important factors in this great work.

I have mentioned incidentally some of the duties of engineers and surveyors at the mines. Every large mine has its engineer and assistants. They are salaried men, and hold honorable, responsible positions. Their duties are various, but not exacting. Many of them are practical chemists and geologists. As civil engineers, they build railroads, and keep them in repair; locate stamp mills, pumping machinery, engine, shaft, and rock houses; and, in short, they look after the *mine plant*. Under ground they have various important duties.

The best hoisting, transit, and drilling instruments are used by them. Great exactness is required. The magnetic needle cannot be depended on in their work. The rocks are so full of iron as to render a common compass untrustworthy. The local variation or deflection is often 20° to 30° in one-half mile. In the woods, the best surveyors have been led astray by the compass, so as to become absolutely lost.

In the iron mines the dip needle has been a useful instrument in the search for hidden lodes or beds. In explorations for copper, this instrument has not been of practical importance.

In engineering, all important work is carried on by triangulation from a base and determined true meridian.

The timbering in mines, where, as the miners say, the ground is "*balky*," is a matter of first importance. The engineer and timberman are called upon to exercise skill and courage. The hanging wall, after the vein matter has been removed, is a great overhanging cliff. If the ground is seamy or shattered, great masses fall. Good timbering prevents this, but in some fissure veins, the best timbering serves only a temporary purpose. The

dynamic forces at work in the earth's crust, sooner or later close up the openings. The largest timbers are as reeds. The slow, imperceptible, but mighty movements of the rocks, "broom up" the ends of the big stolls, and reduce them to pulp, between the closing jaws of the walls.

In the heart of the mines, at Houghton, a miningl school has been established by the State. A very handsome bu iding of red sandstone, found at Portage Entry, ten miles distant, has been erected on the sightly shores of Portage Lake. Under an able corps of instructors, this institution is doing a grand work. The students are taught higher mathematics, chemistry, mineralogy, geology, and civil, mining, and mechanical engineering. These studies are supplemented by actual work or observation in the field, mine, smelting works, rolling mills, stamping mills, and engine and machine shops. The advantages afforded for practical observation and application are unexampled in this country.

JOHN H. FORSTER.

MANIPULATION OF IRON AND STEEL, AND SIMPLE FORGE-SHOP TESTS.

TESTING of iron and steel in the forge-shop by engineers is of much more importance, and ought to have more attention, than it usually receives. I have talked with quite a number of engineers and architects who said they could not tell good iron from poor iron, and relied almost entirely upon the brand, which is all right in some cases, but will not answer in others. An iron may be very good for one thing, and very poor for another, which makes it necessary to determine whether the iron is fitted for the work in question.

In this brief paper, I will give a few important tests that can be made in the forge-shop. These tests should really accompany those made on the testing machine.

First, it may help us to understand the working of iron if we know its nature, and how it is produced. I must say I consider this important. Only a short time ago I was talking with a gentleman in Detroit, who said he had trouble with working his iron, and could not account for it. I found he had been working it wrong.

Now I will give a hasty outline of the production and nature of iron alloys, for that is what commercial iron is.

Chemically pure iron exists only as a laboratory specimen, and would be of little use on account of its softness and tendency to rust.

Some of the elements improve the quality of the iron, under certain conditions and for certain purposes; as, for instance, carbon in the graphite state makes pig iron, and in the combined state,

makes chilled iron and steel. Other elements, as sulphur and phosphorus, injure iron, and render it poor for almost any purpose. Iron or its alloys is divided into three great classes, and these again subdivided into many more. I will give them in the order in which they have come into use: (1.) Wrought Iron; (2.) Steel; (3.) Cast Iron.

The first two of these have been known and worked from the beginning of history, but the last one is of recent date; and I think we may look for other alloys in practical use before many years.

Wrought iron was produced from very rich ores piled in with great quantities of charcoal in a pot-shaped hole in the ground, and blown by some crude, artificial means. The air was directed on the melted metal somewhat, and the metal was kept stirred with a rod. This decarbonizes it, and leaves a pasty mass instead of a liquid. This mass is called a "bloom," and was drawn out under the hand hammer and thoroughly welded together; this squeezes the slag out of it as well. Charcoal was the only fuel for centuries, and is the best to-day, but cannot be obtained in sufficient quantities to supply the market. About 1600 A. D., pit-coal began to be used, and in 1700, coke. Since then, the iron industry has developed into enormous proportions, aided by the steam-hammer and the steam-engine. Later on the *direct* process of making wrought iron was invented. The product of this furnace is called a bloom, the same as in the primitive furnace, but the blooms are drawn out under the steam hammer, and not by hand. *I wish to call your attention to the blooms as they are taken from the furnace, as this will help us in understanding wrought iron.* The blooms are fibrous and stringy. Perhaps an illustration may make it more clear. If we should take a large number of small rods, bent in all sorts of shapes and tangled together, put them into a furnace, and heat to a welding heat, with a little sand thrown on them, we would have a very good bloom. The fibers or rods lie in every direction; and if we pound the mass into a plate or slab, the fibers lie in one plane. Then the plates are cut, re-heated, welded, and hammered on four sides. This makes shear iron; if the process is repeated, it makes double shear iron. These irons are used in the merchant bar. This kind of iron is tough and fibrous in the direction of its length, if well puddled and welded. But if not well worked, it is apt to be seamy, and crack easily. The shearing and re-shearing up to the sixth time improves the iron. Then it ceases to be of value, and becomes injurious. This process is rarely ever repeated more than twice. In 1856 the Bessemer process of making wrought iron and steel was invented, by which the iron was decarbonized by forcing a large number of small streams of air through it. This freed the iron from carbon and most of the other impurities, and then the iron was cast into ingots. These ingots are very homogeneous and ductile. When cast, they are not fibrous, but seem to be a mass of globules or grains held firmly to-

gether. When the ingot is rolled, these globules seem to elongate, and to resemble fibers to some extent. This kind of iron is stronger and more ductile than bloom iron, and is also free from flaws.

Steel, the next alloy of iron, dates back almost as far as wrought iron, and was made in the same primitive furnace by leaving enough of the carbon in the iron to make it harden and temper. This steel might, under very favorable circumstances, be quite good ; but generally it was poor, unreliable, and full of flaws. Mild steel, and even some grades of high steel, are produced in the Bessemer converta by first decarbonizing cast iron, then adding just enough carbon to make the quality of steel required, and then casting into ingots, and rolling into the required shape. This steel is malleable, and can be welded when it contains less than one per cent of carbon. Tool shear-steel is made by heating very fine grades of wrought iron in a furnace with layers of charcoal, and keeping at a red heat for from ten to fifteen days. This is called the cementation process. Crucible steel is made from cemented steel by melting in a crucible, casting into ingots, and drawing out into bars. This steel is very homogeneous, and will harden to a great degree. Crucible steel can be made by melting small pieces of fine iron in a crucible with charcoal. This steel has been made for about 200 years, and has from 81 hundredths of one per cent to one and one-quarter per cent of carbon.

Cast iron is a direct product of the ore when it is melted and drawn off without being decarbonized. Strange as it may seem, it appears to have been put to but little use till within about 300 years. The art of making large castings, and the use of the cupulo furnace, belong to the work of the last 120 years. Cast iron does not properly belong in this paper, and I will drop it here.

Testing of wrought iron and steel in the forge shop, to determine whether the metal in question is good, bad, or fitted to its use, is a very interesting piece of work. Usually the testing machine would do some of this work better, and will of course do work that cannot be done in the shop ; but on the other hand, the forge shows things that the testing machine will not.

HEATS.

There are four principal heats, as follows: First, low red or cherry heat, where the iron just turns red ; second, red heat ; third, white heat ; fourth, welding or sparkling heat, where the iron begins to fuse ; but as soon as the iron looks greasy, it should be removed from the fire, as the high heat oxidizes the iron, or burns it away.

FLUXES.

The fluxes used in welding are quartz sand for wrought iron and low steel. The silicon unites with the oxide of iron, and

forms the silicate of iron, which is a slag. This forms a greasy coating over the iron, and protects it from further oxidation.

When the iron has reached the welding heat, the two pieces to be welded are brought together and the blow struck, the slag squeezes out, and the bright iron unites. Borax is perhaps a rather better flux. I find a large number of blacksmiths who do not know what they use borax or sand for, but seem to have an idea that it acts as a sort of cement to stick the iron together, whereas if they knew the real use of the flux, they would use less of it on clean iron than on rusty. An excess of flux, and consequently of slag, is objectionable. Borax should be used for most steels containing less than 75 hundredths of one per cent of carbon. It fluxes better, and forms a thinner coating on the iron. The borax should be first heated to expel the water, as it contains a large amount of it. When it is required to weld steel of a high grade, the flux used should be one part of sal ammoniac and sixteen parts of borax. The sal ammoniac cleans the steel a little better, so it is well to use a small amount of it with borax. High grades of steel must be worked at a low white heat, as the carbon at a high heat has an affinity for oxygen, and will leave the steel. High steel will weld at a much lower heat than wrought iron, as the carbon helps to flux the iron at a low temperature.

HARDENING.

Wrought iron will not harden at any heat when plunged in water. But poor wrought iron containing some carbon will harden in spots. Steel with less than 15 hundredths of one per cent of carbon will soften when plunged into water of less than 60° F. But all grades of steel with more than 15 hundredths of one per cent of carbon will harden in water at 60° F. The proper heat for hardening is from cherry red to red. Cast iron will chill when heated and plunged into cold water.

HARDENING FLUIDS.

When it is required to harden steel, we have to use some substance that will remove the heat quickly; the quicker, the harder the steel. Some form of liquid is generally used. For a moderate degree of hardness, used tallow. For a little harder, use lard oil at 60° F.; next, water at 60° F.; next, salt and water very cold; and for very hard, use mercury. This will make the steel hard enough to cut most substances except the diamond. All of the hard steels are very brittle.

TEMPERING.

Tempering is the process of reducing hardness. All ordinary steels when hardened are capable of having the hardness reduced by heat. The heat required to draw the temper is quite low, about

400° to 500° F. Cast iron will harden, as we have seen, but will not temper much. When it is required to temper a piece of hardened steel, the surface is first made bright; then heat is applied; at first a yellowish white or bright straw appears, then a dark straw, golden color, brown, purple, violet, and deep blue. These colors form what is known as the tempering scale. All degrees of hardness come between the two extremes. The details of hardening and tempering would make a long paper. There is one steel on the market which will not temper; that is, Mushitt's, an alloy of tungsten and iron. This steel is very tough. The Damascus steel was probably of this alloy, quite easily made and of good quality; but some are inclined to think that this steel owes as much to poetry and literature for its reputation as to its actual merits.

ANNEALING.

When steel has been hardened, it can be softened again by heating to cherry red, and allowing to cool very slowly, the slower, the softer the steel. This is the reverse of hardening. Chilled cast iron or hard wrought iron can be softened in this way.

MALLEABLE QUALITIES.

Good wrought iron or steel when heated to a cherry red heat can be drawn out to a point without cracking, or can be flattened as thin as tin plate without showing flaws. Cast iron has no malleable qualities, but malleable cast iron can be worked to quite an extent. Good wrought iron can be worked up to the welding heat without injury, but steel of a low grade should not be worked above white heat, and steel of a high grade, at a red heat. Poor wrought iron and poor steel when heated to a red heat and drawn to a point, will crack. It will not stand working into any shape to any extent.

Iron or mild steel may be considered fairly good for forge work, if it will extend one and one-half to two times its original width at cherry heat without cracking. But high grade steel and tool steel will not stand working at a high heat. The high steel should show no signs of cracking at cherry heat, when drawn out to any extent. Poor wrought iron will draw into most shapes at the white heat, unless it is hot-short.

SHORTNESS.

Iron is cold-short if it is brittle when cold. This kind of iron is very poor for any purpose. Red-short iron is brittle at the red heat. Hot-short iron is brittle at the white heat. This last kind of iron may be quite stiff and tough when cold, and is a good iron for some places. Steels are all more or less hot-short.

TO TEST THE QUALITY OF TOOL STEEL.

Take a piece of tool steel, heat to a red heat, draw into a cold chisel of about 30°, grind to an edge of 60°, harden at a cherry-red heat in lard oil at 60° F. Draw the temper down to a purple color. This chisel, when finished, should cut bar iron and annealed steel, cold, without cracking or chipping, if the steel is good. Low steel or wrought iron will not do this. A very good way of finding out at what heat a piece of steel will harden is to take a bar one-half by three-fourths of an inch, and make nicks an inch apart for about eight inches, and place in the fire so the first piece will get white hot and the last barely red. As soon as it is heated, plunge in water at 60° F., then break the bar up at the notches. No. 1 will be very hard and brittle, while No. 8 will be soft. This is Miller and Metcalf's way of testing and examining the fracture. And right here I want to say that Crescent steel, made by Miller & Metcalf, of Pittsburg, is the best I ever used. But ordinarily, mechanics will get a better idea if they should take each one of the pieces, and grind the end to the shape of a lathe tool, and try the cutting qualities in the lathe. The piece that cuts the best for the longest time, will show what temper to use. The pieces could be tested by grinding into cold chisels just as well.

WELDING QUALITIES.

Good wrought iron, and most of the poorer qualities, except iron containing copper, sulphur, and phosphorus, will weld at the welding heat by the use of fluxes. They will look greasy at the high heat. The more fibrous the iron, the better it welds. To test the weld, bend the bar at any place around round iron until it breaks, then bend the weld over the same bar through an equal distance. If this weld holds, it is very good.

Steel, unless very low, will not weld at the high heat on account of cracking. Steel containing more than one and one-fourth per cent of carbon will hardly weld. It, however, can be welded at the white heat with care by using the proper fluxes. It will not do to heat the steel to the welding heat, as the carbon at this heat has too much affinity for oxygen, and will leave the steel. The carbon, however, helps to flux the steel at a lower heat.

Wrought iron which does not weld well is unfit for forge work. But some of the poorer grades may be very good, if they are not to be welded, where stiff iron is required.

UPSETTING.

Good wrought iron and steel should stand upsetting, at a red heat, to one-third of its original length, without cracking. The test pieces should be short. Poor wrought iron will not do this, except at the high heat, and some of it not then. Iron would not

be considered very poor if it would upset to two-thirds of its original length.

Mild steel, if good, will upset to almost any extent. But tool steel should never be upset where it has to stand shocks. It will, however, stand upsetting a large amount without cracking.

HOT BENDING.

Good wrought iron should bend at the white heat around a sharp corner double without cracking. A fairly good iron should bend around its own diameter. Poor iron will not do this. Steel of all grades should bend around a square corner double.

These tests are in the direction of the fibers. Good iron and steel should bend about as much across the fiber as lengthwise. Poorer iron, if fairly good, should bend about one-quarter as much across the grain.

COLD TESTS. — MALLEABLE QUALITIES.

Very good soft wrought iron and very low steel should stand drawing out about one-tenth of its original length without cracking. Ordinary iron will not stand drawing cold. If an iron cracks and breaks easily when cold, it should not be used.

BENDING.

Very good soft iron up to one inch in diameter and one inch thick, should stand bending double without cracking. No iron should be used for intricate forging which will not bend on these diameters up to two inches in diameter.

Construction iron, according to Thurston, should bend cold, as shown by the following table : —

Inches.	Bar Iron.		Bolt Iron.		Cast Iron.	
	Longest inclined.	Transverse.	Longest inclined.	Transverse.	Longest inclined.	Transverse.
.24						
.24 to .28	50″	30″	80″	50″	110″	90″
.32 " .36	45	25	70	40	100	80
.40 " .44	40	20	60	35	90	70
.48 " .52	35	15	50	30	80	60
.56 " .60	30	12	40	25	75	50
.64 " .68	25	10	35	20	70	40
.72 " .76	20	8	30	15	65	35
.80 " .84	15	5	25	10	60	30

Good iron should stand bending across the grain about half as many degrees as with the grain ; fairly good, one-third as many

degrees. Very poor iron will stand bending but very little across the grain.

When a bar three-fourths of an inch in diameter, with a thread cut on it, is bent cold, it should show a crack of less than one-eighth of an inch.

When the machinest cuts the thread on a bar and it crumbles off and shows a large number of small seams, it should not be used without testing in the forge shop.

FRACTURE.

A bar of very good iron, when broken, will show a tough, fibrous structure, free from flaws, and of a dark leaden color. It should show no crystals. Poorer iron may show some seams and little spots of crystals, but the fibers should be tough and of a leaden color. Iron for bridge work should be as free from crystals as possible, and should not be strained beyond a certain limit, as the constant strain and jar tend to crystallization. The oftener the jar, the less the strain should be. Low steel, when broken, should show some fiber and a close grain with a bright luster. Tool steel should have a very fine grain, and a higher luster.

COLD HAMMERING.

This should be avoided, as the best iron, when hammered cold too much, will become crystallized and brittle.

C. G. TAYLOR.

PRACTICAL NOTES ON RAILWAY LOCATION AND CONSTRUCTION.

IN attempting to comply with the request of our worthy Secretary to contribute a paper to be read at this meeting, it has occurred to the writer that a brief account of the work upon which he himself has been engaged for the past two years, together with such comments as his experience may from time to time have suggested, might possibly be of some interest to at least the younger members of the Society. He does not expect to present a single idea that can be called original, nor does he claim that the methods which he adopted were in all cases the best. He only proposes to offer for your consideration an example of engineering construction which has been proved by actual use to be safe, ecomomical, and successful, the most important qualifications to be sought for in all engineering works.

The Chicago, St. Louis & Paducah Railway, of the location and construction of which the writer had charge as Chief Engineer,

extends from Marion, Illinois, to Brooklyn, a small village on the north bank of the Ohio River about three miles below Paducah, Kentucky. It was intended as an extension of what is known as the Cairo Short Line System, and this circumstance limited in some degree the choice of plans for structures to such as would conform as nearly as practicable to the standards which were in use on the old road.

The entire length of the road is fifty-three miles, of which the first ten on the north end are over a rolling country presenting no special difficulties either in location or construction. The next section of five miles crosses the divide between Saline and Sugar creeks, and includes several heavy cuts and some rock-work. Then comes the most rugged and difficult section of Illinois, the crossing of the Ozark Range, a high, rocky ridge, which extends entirely across the State, and therefore could not be turned.

Its summit has a very uniform elevation of about 440 feet above low water in the Ohio River, and presents but few passes favorable for a railroad line. It is composed almost entirely of sand rock of every variety of hardness, and its slopes, deeply cleft by long, rugged, and precipitous ravines, and clothed with dense forests, which often confined the view to the limits of a few rods, fall off so abruptly in both directions, especially to the south, as to present very great difficulties in the way of the economical construction of the road.

From the southern foot of this range the line runs for several miles in a valley shut in on both sides by lofty spurs which shoot out from the main range. It then passes a divide into the immediate valley of the Ohio River, which presents no serious obstacle except the deep gorges cut by the tributary streams, and calling for some of the most expensive structures on the road.

Most of the difficulties of location were met with on about six miles of the Ozark Division, owing to the abrupt descent of the streams, which was more than 200 feet in a mile, and the rugged character of the slopes, which made a surface line entirely impracticable. The best general route was determined by means of preliminary lines run through every gap which appeared at all practicable, but the limits of this paper will not permit any account of the methods employed.

After this had been accomplished, the first important point to be determined was the gradient to be adopted. On the other divisions of the road a maximum gradient of one per cent had been found practicable, and our preliminary surveys showed that by developing the line to a length of about eleven and one-half miles by means of long loops and horseshoe curves, this same gradient could be carried over the ridge. This, however, would have involved an expense which the financial condition of the company would not warrant, and it was determined to build the road on a temporary line, which would answer perhaps for years, until its

business should develop to such an extent as to require something better. For this temporary line the gradient adopted was $1\frac{1}{4}$ per cent, or 99 feet per mile, and for the following reason: —

Supposing an engine to be pulling its maximum load for a one per cent grade, as would ordinarily be the case with a freight locomotive, it would be obliged, on arriving at the foot of the ridge, either to divide its load and make two or more trips to the top, or employ one or more pusher engines to help it up. It was not desirable, nor did the character of the country require, that *more than one* pusher should be employed, and the choice was therefore confined to a gradient up which two engines could take all, or one engine one-half, of the maximum load. According to the "Tables of Maximum Loads for Locomotives," given in "Wellington's Economical Theory of Railway Location," which are the most convenient and reliable that we have, this would call for a gradient of 2.06 to 2.16 in 100, according to the style of engine used, and, as a general rule, nothing would be gained in economy of operation by adopting any flatter gradient than this, as this would not affect the maximum load on other portions of the road. It was found, however, that a gradient of 1.875 in 100 could be fitted to the ground without any additional cost for construction, and it was therefore adopted for the sake of the small saving in resistance in bad weather.

This maximum gradient was used only on tangents. On the curves, which constituted more than fifty per cent of the Ozark Division, it was reduced at the rate of 0.05 for each degree of curvature. Thus on a 7° curve, the gradient would be $1.875 - (0.05 \times 7) = 1.525$ in 100. From the slight opportunities for observation which the writer has had since the completion of the road, he is inclined to think that possibly this reduction is slightly more than is necessary, and that on a curve compensated to this extent, a train will run a little more easily than on the corresponding tangent. The error, however, if any, was on the safe side.

I mention this matter for the purpose of calling the attention of my younger brethren of the profession to the fact that this practice of reducing gradients to compensate for curvature, though of comparatively recent origin, is now being very generally adopted among the best engineers, and that if they desire to keep up with the procession, they must follow the example.

The rugged character of the Ozark Division required a large amount of sharp curvature, 10° being the sharpest admitted, while 6°, 7°, and 8° curves were numerous. These curves were all flattened at their extremities, the method pursued being that given by Trautwine in his work on "Curves." This method is not very scientific, but practically it answers a very good purpose, and was adopted partly on account of its simplicity, but especially for the reason that it need not be applied until the cross-section stakes are to be set, and the locating engineer, who

has enough head work to do as it is, can make his calculations, and run his lines without taking any account whatever of the flattening of the curves.

While on the subject of field calculations, it may not be amiss to call the attention of the younger members of the Society to a formula which the writer has found of very great value in his field work, and which might be of equal value to them. He learned it from Prof. W. M. Gillespie of Union College, more than thirty years ago, but has never seen it in any published field book, and has reason to believe that few engineers are familiar with it, or at least with the numerous uses that can be made of it. It expresses the divergence of a curve from its tangent, and takes the form —

$$x = \tfrac{1}{8}\, n^2\, D,$$

in which X is the offset or distance of one end of a curve from a tangent passing through the other end, D is the degree of curvature, and N the length of the curve in chords of 100 feet each. Thus a 6° curve will have diverged from its tangent at the end of 500 feet, $\frac{1}{8} \times 5^2 \times 6 = 131\frac{1}{4}$ feet. By making D equal the difference of the degree of curvature of two curves of different radii but having a common origin, X will be their divergence from each other at the end of N stations. This formula is not mathematically exact, and therefore gives only approximate results; but it is sufficiently correct practically for all ordinary cases. It is easily remembered; it requires no tables; and with its aid, with such modifications as a little ingenuity will suggest, and a table of actual tangents for a 1° curve, the locating engineer can solve almost any case that will ordinarily arise in the field. For example: Suppose a 5° curve to the right 8 stations long has been located, and its extremity falls 28 feet too far to the right to throw the tangent on the best ground. Making $x = 28$, we obtain $d = \frac{1}{2}$, showing that a 4° 30′ curve starting from the same origin would pass through the required spot. Again: Suppose that in this same case the new curve is to commence 200 feet back of the first one; then the required divergence from the tangent will be $\frac{1}{8} \times 8^2 \times 5 - 28 = 252$. Substituting this value for x, and making $n = 5 \times 2$, we have $d = 2.88 = 2° 53'$.

This formula will also solve several problems in track laying. For instance, making x = gauge of track, and d = the degree of curvature of a turnout track, or corresponding to a given number of frog, n will be the lead of the main frog. With $x = \frac{1}{2}$ gauge, n = lead of crotch frog, and with x = throw of a stub switch, n will be the free length of the switch rail. Other instances might be given of the uses of this formula, but we will now return to our subject.

All changes of grade exceeding 0.5 in 100 feet were rounded off by vertical curves calculated by the formula for a parabola. At summits these curves were usually made 600 feet long, but when

they occurred at the foot of grades, where the effect of the change is much more severe and dangerous through its liability to cause the train to leave the track or break in two, they were made from 800 to 1,200 feet long, according to the magnitude of the change. This is another point in construction which has not until comparatively recent times, received as much attention as should have been given it.

Our embankments were usually made 14 feet wide on the top at sub-grade, with side slopes of 1½ to 1, and the excavations 20 feet wide on the bottom, with slopes of 1 to 1 in earth, and ¼ to 1 in rock. These proportions are in very common use in this country, but, where the finances of a company will warrant an increase of one or two feet in these widths, it would undoubtedly be very desirable, especially on embankments more than ten feet high.

For all small water-courses, the double-strength culvert pipe of vitrified clay, made at St. Louis, Mo., was used. These are thicker and much stronger than the ordinary sewer pipe, the thickness being not less than one-twelfth of the diameter. Only pipes of twelve or fifteen inches diameter were used, and where one line was not thought sufficient to pass the water, two and sometimes three lines were laid. The pipe cost, delivered on the cars at East St. Louis, eighteen and twenty-four and three-fourth cents per lineal foot, and the handling and laying cost thirty-nine and forty-five cents per foot.

There are eleven Howe Truss Bridges, each a single span, one 94 feet, and the other 66 feet long between centers of end blocks. The chords and braces of these bridges were of yellow pine, the finances of the company not warranting the use of iron. The 94-foot span cost $2,650, and the others $1,550 and $1,700 each, for the superstructure alone. Pile abutments were used for all of these bridges except one, where, on account of rocky bottom, framed bents were employed. This course was adopted because, although the road ran for so many miles through a rocky country, and many thousand cubic yards of rock had to be removed, but very little could be found that was suitable for bridge masonry. For the same reason, there were but four stone culverts on the line, all of which were fine specimens of arches of four feet span under high embankments.

The Cairo, Vincennes & Chicago Railway is crossed overhead by a riveted iron girder bridge, 44 feet in length, resting on iron bents supported by stone piers. This bridge, on account of its unusually sharp skew of about 23° is quite an interesting structure.

It may not be out of place here to remark, in passing, that the writer's experience with this crossing has served to strengthen the conviction which had long been growing upon him that the time is fast approaching, if it has not already come, when all crossings of railroads at grade should be absolutely prohibited. Even with

the present great cost of an overhead crossing, it is a question whether it is not more than balanced by the diminished cost and danger of operation, and the rapidly growing use of automatic couplers, by doing away with the necessity of brakemen standing on the roofs of freight cars. This method of diminishing by about six feet the necessary clearance, and thereby reducing the cost of an overhead crossing more than fifty per cent, promises to hasten the day when a grade crossing will be a thing of the past.

With the above exceptions, all openings are crossed by pile or framed trestles, the former being used exclusively except on the Ozark Division, where in five cases the occurrence of rock bottom compelled the use of framed bents. These five cases included all the highest trestles on the road, one of them being 60 feet in hight. When these framed bents exceeded 20 feet in hight, they were built in two or more stories, the upper stories being of a uniform hight of 16 feet, leaving that of the lowest story to come what it might. The individual bents are stiffened by sway bracing of the usual form, and are tied together at each story by four or more horizontal ties, 8 x 8 inches, notched and bolted to the caps and posts. No inclined braces were found necessary, even for the highest trestles, though they would no doubt have added to the strength and security of the structures.

The caps of framed bents are secured to the posts by the usual mortice and tenon joint; those of pile bents are secured to the tops of the piles by drift bolts. The latter method of construction, though superior to the former, both in cost and durability, is not entirely satisfactory, on account of the difficulty of removing the caps when decayed. For this reason it is probable that both methods will eventually be superseded by the system of split caps, which consists of two pieces, 6 x 12 inches, placed from 4 to 8 inches apart, resting on shoulders cut on the sides of the piles or posts, and secured by bolts passing through both pieces and the post. Although this system brings back the shoulders, which are objectionable as affording a lodgment for water, the ease with which the caps can be removed for repairs, without interfering with traffic, will eventually overcome all objections.

The spans of the trestles were 15 feet between centers of bents, and the stringers extended over only a single span. This is not the best nor the strongest construction, but the difficulty and cost of obtaining long sticks in a territory which had been largely stripped of suitable timber, compelled its adoption as a general rule. The stringer under each rail consists of two pieces, 8 x 16 inches, packed 3 inches apart with a wooden packing block 18 inches deep and 4 feet long. The packing blocks are notched 2 inches over the caps, and thus serve very efficiently to keep the bents at their proper distance apart, and prevent any longitudinal movement of the stringers. But notwithstanding this advantage, this construction is objectionable on account of the large surface

which it offers for the lodgment of water. It would be better to insert iron spools or washers between the packing blocks and the stringers. Some engineers use the spools without the packing blocks, but in this case the longitudinal movement of the stringers must be prevented either by the use of iron clamps, or by drift-bolting the stringers to the caps, a very objectionable method, on account of the difficulty of replacing the stringers when decayed. In the case of a transfer incline, however, this construction may be unavoidable, as will be hereafter noted.

Any lateral movement of the stringers is prevented by spreading blocks 3 x 10 inches, spiked to the tops of the caps.

The ties are 6 x 8 inches, and 9 feet long, dopped one inch over the stringers, and spaced 15 inches between centers. There are guard rails, 6 x 7 inches, dopped one inch over the ties, and bolted to every third or fourth tie. These serve the purpose of keeping the ties from bunching, and preventing a derailed train from leaving the structure.

There are no side or jack stringers. These attachments are recommended by many of our best engineers, and are certainly very useful to the unfortunate pedestrian who finds himself confronted by a train on the trestle, where he ought not to be at such a time; but they add much to the cost and very little to the strength of the structure, and it is at least an open question whether they should ever be used.

The use of wooden trestles for crossing water courses seems to be in many cases unavoidable, especially by new companies struggling along with scanty means. They undoubtedly effect a large saving in the first cost of a road, but even when built in the best manner, they are open to very serious objections. The liability to accidental or malicious destruction by fire, and the necessity of constant watchfulness to guard against the insidious effects of decay, make them objects of suspicion, to be avoided whenever it is possible. The $180,000 which the Toledo, Peoria & Western Company paid for personal damages alone, arising from the disaster at Chatsworth in 1887, which was the result of the accidental burning of a small trestle, would have gone far toward equipping the whole road with first-class stone culverts; and who can foresee when or where such an accident may occur again? Where stone for a culvert and earth for an embankment can be obtained at any reasonable cost, a wooden trestle should not be permitted; and where stone cannot be obtained, a wooden box culvert may often be employed with great advantage. Twenty years ago such a structure would have been considered very bad practice, but recent experience on some of the greatest railroad systems in this country has demonstrated that it is safer and more durable than a trestle, and can be renewed without great difficulty, especially with iron pipes.

The most important trestle on the road is one which was built for the purpose of a transfer incline at the southern terminus of the line. As many of the members of this Society may never have had an opportunity to examine a structure of this kind, a brief description of this one may not be without some interest.

The object of an incline is to furnish a means of transferring a car or train from a railroad track onto the deck of a boat, and the reverse, thus answering the purpose of a bridge in transferring it across a stream. It consists usually of a trestle or rock embankment running down into the water of the stream to such a depth that at low water a boat can lie over it. If there is any current in the stream, the incline must of course point *down stream* as nearly in the direction of the current as practicable, as otherwise it would be difficult or impossible for the boat to use it. On this track rests a *cradle*, which is a kind of car whose longitudinal section is triangular in form, the lower sills being parallel to the incline, and the upper ones horizontal, or nearly so. This cradle is pushed down or pulled up to the incline by the locomotive until the track which is laid upon it is at the proper elevation above the water. The outer end of the upper chord of the cradle projects several feet beyond the main structure, and is attached to it only at the inner end, where there is a hinge joint, around which it has a free but limited vertical movement. The outer end is built in the form of a triangular recess faced with iron, into which a corresponding projection on the boat fits closely. An inclined apron projects from the brow of the boat, which, as it approaches the cradle, catches under the free end of the projecting chord, and lifts it up to its place. The boat and cradle are then secured together by turnbuckle screw bolts working in lugs attached to the sides of the two tracks. A car or train can now be pushed down the incline onto the cradle, and thence onto the boat, which conveys it to the other side of the stream, where it is drawn off onto a similar cradle and incline. This method of transferring cars is used very extensively on the Ohio and Mississippi rivers.

The boat may be built with either one or two tracks, but the latter is the more common construction. The incline also may be either single or double tracked, the latter being much the better where a double track boat is used; but when, for the sake of economy, only a single track is built, it must be located so as to fit the outer track of the boat, as otherwise this track could not be used at all.

The boat is usually made long enough to hold from six to eight freight cars on each track.

To enable the boat to land at the cradle, a row of clusters of guide piles is driven on the shore side of the incline. These clusters are driven from 25 to 50 feet apart, and should extend from a point opposite the lower end of the cradle, when it stands on a level with the top of the incline, to a point from 100 to 200

feet below the lower end of the incline, according to the length of the boat. Each cluster contains from three to five piles, driven about four or six feet apart, and drawn together at the top, and confined by strong chains, so as to make them act, as far as possible, like a single pile. These clusters should be driven with their outer faces at a distance from the center line of a double track incline equal to half the beam of the boat, unless, as is frequently the case, a landing barge is interposed between the boat and the guide piles, in order to distribute the shock of the boat over several clusters, in which case this distance must be increased by the width of the barge. In case of a single-track incline and a double-track boat, this distance must be increased by half the distance between the centers of the tracks on the boat. This last distance is commonly 12 feet, but in the "Geo. W. Parker," the boat used at Paducah, it is 14 feet 8½ inches.

The piles in these clusters are usually driven until their tops are from 15 to 20 feet above the track of the incline immediately opposite them, so that at high water many of them are entirely submerged. It is better, however, to have one or two of the piles on the boat side of each cluster project 8 or 10 feet above the others, so as to prevent the boat from dragging her guards over the tops of the clusters, to her possible serious injury. For a similar reason, notches should be cut on the boat side of the cluster piles into which the chains which confine them can be sunk, so as to prevent them from tearing the sides of the boat.

The extreme rise of the Ohio River at Brooklyn, from low water mark to high water, in 1884, was about 53 feet, and as it was determined to make the upper end of the incline one foot above high water, and the lower end 6 feet below low water, a total fall of 60 feet had to be provided for. As actually constructed, the incline will be, when completed, 1,538 feet in length, of which 1,290 feet have a fall of 3.4 feet in 100, and 248 feet at the lower end, which will be used only in low water, and will then be occupied almost entirely by the cradle, which has a fall of 6 feet or more in 100. An additional length of 420 feet of trestle connects the head of the incline with the brow of the bluff, on which the Brooklyn yards are located.

The entire incline is built upon pile, even through a cut several feet deep, which it was necessary to make.

A structure of this kind is subjected to very severe strains from drift wood and ice, which sometimes pile up in enormous masses, and more than ordinary care must be taken to prepare it to resist these strains. For this reason, the plans in use elsewhere on the road were somewhat modified. The stringers were made long enough to cover two spans, and laid so as to break joints. Each stringer was secured to the caps by drift bolts; each tie was drifted to the stringers, and a stick of timber 6 x 6 inches was drifted to the outer ends of the ties to prevent ice or drift from catching

on them. The guard rails were omitted on account of their interfering with the movement of the cradle. In this particular, the writer felt constrained by the necessity of conforming to standards; but if he were building another incline, with entire freedom to carry out his own ideas, he would make the ties at least 11 feet long, and retain the guard rails for their use in binding the whole structure more firmly together.

The construction was carried on in the usual manner until the surface of the water was reached, 263 feet from the lower end of the incline, when a sudden rise of the river drove the workmen away, leaving them barely time to lay the steel rails on the lower end of the finished work.

As there was soon depth of water at this point sufficient to operate the boat, the further extension of the incline was suspended. A day was set for opening the road, and the work above water was completed, when a fall in the river, as sudden and rapid as the rise had been, compelled the speedy resumption of work on the lower end. We had but little over four days to prepare for passing over the first passenger train, and it was very important that the expectations of the management should not be disappointed. The piles for the river work were driven by a pile-driver on a barge. The cutting was at first done by a diver working with a hand-saw, under water, but this method proving very slow and unsatisfactory, a cross-cut saw was attached to a light triangular wooden frame, the apex of which was hung to the pile at such a hight that the saw rested against the pile at the proper hight for the cut-off. This was regulated by a vertical gauge on the bottom of which was a step for the saw to rest on. The sawing was then done by three men standing on a raft, one of whom kept the frame pressed against the pile, while the other two drew the saw forward and backward by means of long cords attached to its handles. With this crude and simple contrivance, the head of a pile was frequently taken off in fifteen minutes. A small rod with a sharp point was then driven into the center of one of the piles, and projected above the water. A drift-bolt hole was bored through the cap, which was then dropped over the rod and weighted down with chains. The diver swung it into its proper place over the piles, and guided the point of the long auger, with which a man on the raft bored the drift bolt holes over the center of each pile. Another small rod was inserted in each of these holes in succession, and over it a section of gas pipe was dropped down onto the cap. The rod was then withdrawn, and a drift bolt dropped down the pipe into the hole, and driven home with a heavy, flat-ended bar working in the gas pipe.

Now came what in some respects was the most difficult part of the work, the erection of the superstructure. In the case of an incline at East Carondelet, Ill., whose construction the writer superintended in 1882, the entire under-water part of the superstruct-

ure was framed in one section on rollers on the top of the out-of-water track, and then drawn down into its place by a tug. This operation required considerable time, and was therefore impracticable in the present case. The track was therefore framed in sections 60 feet in length, covering 4 spans. The first section was framed in the usual way, except that in the upper span the chord pieces were so placed as to inclose the stringers above and below. The joints were so framed as to come as nearly as practicable over the centers of the caps, but the care required to accomplish this, on account of the unavoidable irregularities in the driving of the bents under water, and the weakness which would be the result if the joints were not brought directly over the caps, led to the adoption of a different plan for the remaining sections. The spans were reduced to 13 feet, and the stringers framed in pairs without breaking joints, each pair being alternately inside and outside of the adjoining pairs above and below. The stringers being 30 feet long, each pair extended over two spans, and lapped 18 inches beyond the caps at each end, thus securing a firm bearing, independent of the adjoining pairs, even if there were a variation of a foot or two in the length of the spans. The holes for the packing bolts, which connected the adjacent pairs, were bored about half an inch larger than the bolts, so as to give the stringers a moderate hinge motion, by which they could adjust themselves to any slight irregularities in the hights of the caps, and thus secure a firm bearing.

Work under water can seldom be done with the same precision as on land, and some provision must therefore be made for unavoidable inaccuracies. The stringers were put together on the top of the finished track, the ties dopped and drifted onto the stringers, and the rails laid, and the section was then drawn into the water by the transfer boat, which supported the outer end, while the inner end was suspended from the cradle, and drawn back into its place by men standing on the incline. This last operation sometimes occupied several hours, on account of the difficulties which attend all under-water operations; and on one occasion the diver had his leg broken by being caught between the ends of the fixed and loose rails as they were slipping together. When the ends were once brought together, the fish plates were bolted on by the diver; the section was then weighted down onto each cap in succession, by pushing down the cradle; the stringers were drifted onto the caps; and the work was done.

This paper has extended to such an unconscionable length that the writer omits any description of the cradle which was used on this incline. He has, however, brought with him the plans of this, as well as several of the other structures on the road, for the amusement of any members of the Society who may choose to examine them. It was his intention to have copies made of all of these plans, as well as photographs of some of the structures and of

the natural features of the road, to present to this Society; but the want of time has prevented him from carrying out this intention. He hopes to do so, however, at some future time, and mentions the subject now simply for the purpose of suggesting that the exhibition and presentation of such plans might be made productive of much good to the members of this Society. If each member would at each meeting present the working plans of even *one* structure which he had actually built, we should soon have a set of plans in all branches of engineering, ranging from a board fence to a cantalever bridge, from which we might all get some useful ideas.

Engineering is very largely an empirical science, embodying the best results of the successes and failures of generations of experimenters; and he who expects to plan all the structures which he may be called upon to erect, without any regard to what others before him have done, will soon find that he has attempted to shoulder too heavy a burden. There is not one of us who is not liable to be called upon at any time to plan some structure with which he is not perfectly familiar; and if he could feel assured that in the rooms of this Society he could find valuable hints, if not just what he wants, in the experience there recorded, the Society rooms might in time become a Mecca toward which all our footsteps would gladly turn.

EMERY W. MUENSCHER, C. E.

RAILWAY LOCATION IN THE HILLS AND FORESTS OF MICHIGAN.

LOCATING a railroad line through the forests and among the hills of Michigan in a locality unknown to the engineer, is much like finding an unobstructed path through a dark garret, into which has been piled promiscuous heaps of boxes, barrels, furniture, and everything hard to climb over. While engaged in either occupation, you will be apt to run into something as disagreeable as it is surprising. This unexpected contact will breed thoughts that will hardly be orthodox, and if they are uttered at all, they would better be murmured in a low voice, while you are thus alone in the woods or in the dark.

Before much progress can be made in finding a good location, the country through which the line is to run must be thoroughly known.

The initial and objective points, and probably some places between them, have been decided upon by the business managers of a road, and the question of how to connect these points with a railroad running in the most direct line, with grades as nearly level as possible, and with the least expenditure of money, is referred to the engineering department.

All possible information relative to the topography of the district between these points, is gathered from maps and from people who are acquainted with the whole or a part of the country. The latter, however, should be taken with caution, as will be shown later.

The published maps of the northwestern part of the Lower Peninsula, which we have been able to secure, have been found to be unreliable in marking the location of streams, and in topographical data generally. But information gathered from people and maps cannot take the place of going over the country and becoming acquainted with it personally.

The really valuable information must be gathered from the field by the engineer himself, and placed upon a map of his own construction.

In places where no clearings have been made, the forests are so dense that only a few acres can be seen from a given point, and but little can be learned of the nature of the ground without a systematic examination of the whole region through which it is required to locate a railroad. I have been able to find no rule by which a feasible route can be marked on a map, before walking *over*, *around*, and *through* the hills and in the valleys, unless the information can be obtained from some one like our worthy President, who can mark the exact location upon a map for you. This cannot be called an exception to this lack of a rule, for his acquaintance with the Grand Traverse region was gained by the sweat of his brow.

In the northwestern part of the Lower Peninsula, where the writer is most familiar with the hills, there appears to be no system in their arrangement. The highest hills are mostly yellow sand with now and then a pocket of clay, and where we have made excavations, a few stray boulders have been found. Perhaps a general description of a part of the country will not be out of place here.

The elevations given have been reduced to hights above Lake Michigan, by connecting our levels with an elevation above the lake at Cadillac, furnished me by Mr. G. S. Johnson, Chief Engineer of the G. R. & I. R. R.

Beginning at the Muskegon River in the northwestern part of Clare County, where the water in the river in section 16 T. 19 N. R. 6 W. has an elevation of 429 feet above the lake, the ground rises by two terraces westward to a long stretch of pine plains having a thin growth of brush and jack pines. The first terrace is about twenty feet, and the second about thirty-five feet above the river. The plains rise about twenty feet above the second terrace, and make an ascent of only twenty feet in two miles and a half.

Just over in the eastern part of Osceola County, the plains border the clay hills which are drained by the Middle Branch of

the Muskegon and its tributaries. These hills have an average elevation of 560 feet, but are very rolling and broken, and are frequently cut into by swamps running back from the streams. In the northern part of Osceola County, on the divide between the Middle Branch of the Muskegon and the West Branch of Clam River, the hills attain an elevation of 645 feet. This is eighty feet above the nearest tributary to the Middle Branch, and less than three quarters of a mile from it. Here the material is sand and gravel.

The ground then drop ssixty feet in a mile and a half into the valley of the West Branch of the Clam. It then rises to the rough sand hills which have their summit in the southeastern part of Missaukee County and the southwestern part of Wexford County. The highest point in these hills over which we have run levels, is 818 feet. Other points which we missed must be thirty feet higher.

The highest point of grade on the Toledo, Ann Arbor & North Michigan Railway is among these hills (on section 18, T. 21 N. R. 8 W.), being 803 feet above Lake Michigan.

Dr. Winchell, in his "Topography of Michigan," says that the summit of the northwestern lobe of the Lower Peninsula is among these hills, but we have found places in the Brier Hills about twenty miles northwest of them which is ninety-seven feet higher.

These hills are composed mostly of yellow sand, and covered with a heavy growth of hemlock, maple, beech, birch, pine, elm, and a few other varieties of timber.

They are very rough and broken, cut up by deep dry ravines, running in various directions. Occasionally there is some clay at the bottom of a ravine which holds the water and forms a swamp.

They extend to Clam Lakes at Cadillac, and there present a bluff-like appearance. The elevation of the water in Little Clam Lake is 701.5 feet.

A large flat area lying about eighteen feet above Clam Lake stretches out north and west of Cadillac for a distance of six miles. On the west side of this flat piece there are a number of small lakes, surrounded by soft ground, with a very uncertain bottom.

From this soft ground the land rises rapidly to a plateau seventy-five feet higher. In the southwestern part of Wexford County this plateau terminates in a lot of hills very similar to those just described. They are divided by the Slagle Creek. Those on the north side of the creek are called the Brier Hill Range. The lowest point along the summit of this range which we were able to find, had an elevation of 915 feet. They extend westward to within half a mile of the Manistee River, which is about 740 feet below its summit.

The Slagle Creek is a very rapid stream, having a fall of 426 feet in ten miles. Between the creek and Brier Hills there is a

terrace having about the same fall as the creek, and widening as it approaches the Manistee.

The Manistee River has an elevation of 196.4 near Sherman Village, and is 55.4 feet lower seven miles down stream. The banks on the east side are more easily reached than those on the west side, where a range of hills from 225 to 300 feet above the water lie close to the river. The streams running from these hills into the Manistee are very short, and afford but little means of getting out of the valley.

Among the sand hills most of the ravines do not seem to have been formed by streams of water, and they often terminate abruptly at the foot of irregular knobs from twenty feet to a hundred feet higher.

The courses of these ravines and depressions through which you may at first hope to find a practicable route, are often so irregular that even if they did not lead into insurmountable knobs, they would be useless on account of alignment and the heavy earth-work necessary to cut through the ends of projecting hills.

Many times, a line running directly across these dry ravines will furnish longer tangents, easier grades, and less earth-work than could be found by following the best of them. Such a line might be rejected by a railroad official who has no eye for elevations, if he were to walk over it, unless he was provided with a profile of an actual survey, with an estimate of the work to be done, to convince him to the contrary.

I do not doubt but that engineers who build logging railroads have harder work to make their employees believe this than do engineers employed by railroads doing a general transportation business. When the Government corners are standing in the woods, the location of hills, streams, or anything else can be determined with sufficient accuracy, in the reconnaissance, by pacing.

When riding over section line highways, diagonal roads, or logging roads, distances may be roughly found by measuring the circumference of a buggy wheel, and counting its revolutions. Courses are taken with a pocket compass and comparative elevations with a barometer. While making this examination, lots of information will be offered by people claiming to be acquainted with the country. It will come in all degrees of utility, from the general statements of the old settler who says, "This is a mighty RAVINOUS country," to a minute description given by a lumberman who will tell each forty his route traverses. Another old settler will say that the only way you can get through, is by following a ravine where he chased a bear last season. One of these "only ravines" proved by actual measurement to be nearly a hundred feet higher than ground already selected as holding the best elevations and alignment in that vicinity.

Don't be led too far against your own judgment by men who offer themselves as guides and pilots in showing you through the woods, over what they consider a sure way through a place of difficult location. If the guide is a land owner, he will steer you to a place which will be convenient for him to deliver logs, without much regard for good railroad location. If he is ignorant, there is no telling where he will lead you. I remember one of the latter class who after traveling through the woods several hours, caught sight of his own chopping, and wondered whose clearing that was.

Perhaps when you arrive in town, some lawyer will tell you what a delightful time he had trout-fishing in a stream somewhere near the place you have been looking line, and describe to you a good place for location.

If you should go to the county records, you might find a bit of history running like this: Twenty years ago a mossback entered an eighty near the trout stream. Some years later a non-resident began action against him for cutting the pine off of the adjoining eighty; and still later a big mortgage, with a squeezing foreclosure clause, against a mossback's eighty, and in favor of this lawyer for defending him in his logging enterprise.

If you could look at a picture of the near future, which the lawyer looks at through a blue cloud of tobacco smoke while he sits scheming in his office, you might see a railroad skirting along a mill pond lined with factories. Just beyond is a big brick block with a conspicuous sign of "Lots for Sale" hanging out. Inside the corner office on the ground floor, the lawyer sits amusing his customers by telling them how he used to catch trout down near the mill-dam before there was a tree cut, while his busy clerks are hard at work writing the descriptions of his lots in blank deeds for them. But it does not follow that all schemers are lawyers.

I mention these cases to call attention to the information offered to an engineer when he is in active duty in the woods, that he may apply his knowledge of human nature to search out the motive of his informer, before any valuable time is wasted in finding him actuated by some selfish scheme.

The most reliable information can be found from lumbermen who have done business over a large area, and who have located sleigh roads for long hauls.

In the last year's work, the man who gave us the most accurate knowledge of the country was a farmer who hired out in one of our corps as an axman, and said he had been employed by Mr. Steele in Grand Traverse and Benzie counties, in similar duties. But he had to be questioned to draw out what he knew. It is as true here as elsewhere, that proffered and gratuitous information and opinions are of the least utility. When you want to know something that is of value, it must be sought from people who are too busy to hunt you up to tell you what they know.

While engaged in the reconnaissance, enough should be learned to enable the engineer to draw very accurate outlines of hills, table-lands, valleys, ravines, and to mark the streams on his map, so that he can lay out a course over which to run a preliminary survey, with the assurance that a practicable location can be found near it.

In places which are unusually rough, such as running from a table-land into a deep ravine or valley where the descent is made among abrupt and irregular hills, cut up by ravines and gulleys, or in passing over divides like those found in the southeastern part of Wexford County, and adjacent parts of Missaukee and Osceola counties, a definite course for a preliminary survey cannot be laid down at first.

Several courses are drawn, over which the chief or locating engineer walks with a pocket compass in his hand, and over what seems to be the best route for his purpose. He marks his course on the ground by breaking off brush and fixing pieces of paper on saplings and sticks. In settled weather, an aneroid barometer will be found of great service in aiding a person to keep desirable elevations, but in changing and stormy weather, a good guess will be much more trustworthy.

Then, frequently, several preliminary lines have to be run before the best route can be selected.

At this stage of the work, a party is put into the field to run the preliminary line. In places which present no special difficulties, the preliminary line can be run with the same care that is exercised in running a line for permanent location, cutting down everything, that the tangents may be free from swings.

When the nature of the ground indicates that the preliminary line cannot be adopted as the located line, short tangents are run, without joining them by curves. In the rough places, the broken brush and pieces of paper are followed, improving the line as much as possible. The several lines which have to be run in these places should be connected, and the levels run from the same datum line, in order that a comparison can be easily and quickly made, as soon as the notes have been platted.

Tie lines are used to connect the preliminary line with Government surveys every mile, if possible; but if much hunting is required to find the corners to run tie lines, it will be better to omit them until so large a corps will not be hindered.

If the preliminary work is done with a transit provided with a gradient screw and level attachment, it will afford much assistance in determining the course of lines where the best elevations can be held, etc., and oftentimes help to fix parts of the preliminary line so well that they can be adopted for location.

Mr. F. Hodgman, in his article on "Surveying for Railroads," read before this Society in 1883, tells of the advantages of the gradient screw, in advance of the leveler. In the spring-time,

when flooded districts have to be crossed, and the water is too deep to make measurements, instruct the head chainman in the use of the carpenter's "six-eight-and-ten rule" of laying out right angles. Let him select a hub at a convenient point on the farther side, and lay out his right angle. Turn off 5° 43′, and let him place another hub at the intersection of a line at right angles to the preliminary line at his first hub and the line which is deflected 5° 43′. Measure the distance between the hubs, and multiply it by ten for the unknown distance. The natural co tangent of this angle is 9.98931. In a distance of 1,000 feet, the error would be 1.07 feet, which is as close as most measurements are made in the woods on preliminary lines. This method of triangulation avoids chopping, and the computations are performed mentally, and the progress of the party interfered with but little. With a map drawn on a scale of 1,000 feet to the inch, and one or two good tie lines to begin with, courses of the preliminary lines laid down by the chief engineer can be scaled with a remarkable degree of accuracy by the aid of a good horn protractor. This saves the time of hunting up corners at quite a distance from the line, and calculating courses. When running around hills where pine choppings are covered with a thick growth of poplars and brush, so that the eye cannot penetrate more than six or seven rods, the locating engineer goes 800 or 1,000 feet ahead of the transit, selects the best place to run, and makes a noise, so that the line can be run toward him.

Every one knows that the valleys of streams should be followed when possible. Searle's "Field Engineering" and other text-books teach this and many other things which should be remembered in locating lines in the woods.

When the preliminary work has been finished, the line for location is run as soon as possible, using the map of the preliminary lines as the base of all work. I wish to emphasize what Mr. Hodgman says in his article, above referred to, against the "cut-and-try" method of locating.

Don't do it. It is expensive, takes lots of time, and seldom gives satisfactory results. Before going out to locate, everything which needs to be avoided, and all places which are desirable to use, should be located on the map.

In the woods, telemeters cannot be used to advantage. An engineer with two chainmen proceeds along the line, with no other instruments than a tape line and a pocket compass. Objects near the line can be located at right angles to a regular or plus station, by the engineer's placing himself in line, stretching out his arms in the direction of the preliminary line, then, with head erect, looking out straight.

If the line of vision does not strike the object to be located, move up or down the line until it does. With a little practice, a right angle can be approximated very accurately, and in less time than it would take a needle to settle. If the underbrush is thick,

or the object is too far from the line to be seen plainly, then the bearings are taken with a compass. Tie lines along section lines can be easily followed with a pocket compass, and with a fifty-foot tape line, good measurements may be obtained. When the topographical work has been completed, the notes are platted on the map of the preliminary line in camp or in the office. When this has been done, then all that you want and all that you don't want are arranged to show their exact relation to each other, plainer and better than could be expressed by volumes of words. If all of the work has been well done thus far, a location line can be drawn, and in most every instance followed.

No such progress can be made by cutting, trying, and backing out, when you have spent half a day with a full force of men to find that the position of some desirable spot has been miscalculated, or rather, misguessed.

Swings in located tangents are eye-sores which time does not cure, and almost everybody has too much pride in his work to allow any defect so noticeable to exist, if there is any way to prevent it.

It is easier to run a curve than a straight line. If any one doubts this statement, let him try it in a hilly country where there are occasional swamps, and all thickly timbered.

Short sights caused by ascending hills are to be avoided as fruitful sources of errors of this kind. The extra time used in cutting out overhanging limbs, so as to get a sight of at least 200 feet, will be well spent.

In swamps or in soft ground, long stakes are driven in the same direction the tripod legs are to stand, as a foundation for the instrument to rest upon to insure firmness while walking around the transit. A back flagman would better be promoted to the position of axman, for a back sight plumbed up behind the transit, with two pieces of thin card-board crossed and tacked to it, never neglects its duty. Sometimes it happens that two or three can be seen at a time, giving proof of the accuracy of the work.

The means employed to run a straight line would furnish subject-matter enough for an article too long to be included in this paper.

When an engineering force receives instructions to locate a line between two points, and to be ready to start a hundred men grading in a week, a thorough examination of the country cannot be made, and it will be wonderful if the best location is secured.

When such an order is issued, a connected location cannot be made. Parts of the line where men can be put to work to the best advantage are located first.

Under this condition, it is not always possible to have draughting tools when most needed to plat topographical notes, and whatever comes to hand must be used.

Once I received orders to locate a particular part of the line immediately, so that a gang of clearers could be started next day. Twenty miles of poor road lay between me and my drawing instruments. At a camp which was just starting in some deserted lumber shanties, I found an old rusty square and a piece of brown building paper. I appropriated them for my draughting. In the afternoon I went along the preliminary line, gathered notes, and in the evening platted them on the building paper. The map was drawn on a scale of 800 feet to the inch; angles were platted by using the table of natural tangents; and a piece of tough bark from a sapling, a pin, and a pencil, took the place of dividers to describe the curves.

The next morning I was able to run the located line ahead of the clearing gang.

GEO. L. WELLS.

WHAT A SPECIAL AGENT SAW IN OREGON AND NEBRASKA.

Mr. President and Gentlemen: —

I SEE that I am down on the programme to tell what I saw in Oregon and Nebraska while a special agent of the General Land Office, for the examination of surveys and the unlawful inclosure of the public land by cattle-men, and the fraudulent entry by pre-emption by the employees of these cattle-men or syndicates, in their interests. Being absent from home, I did not receive the programme from the Secretary in time to put down on paper what I saw, therefore I am compelled to give you a sort of extemporaneous speech of what I saw, to give you a general idea of the errors carelessly made in the public surveys in the State of Oregon, which I have represented by a diagram upon the blackboard.

I was instructed in the spring of 1883 to repair to Oregon and examine that portion of the Grande Ronde Guide Meridian, between the 4th St'd parallel S. and the 7th St'd parallel S., a distance of ninety-six miles, to ascertain where an error occurred of between two and two and one-half miles demonstrated by the running and marking of the 7th St'd parallel; and also the 6th St'd parallel west from the meridian, and nine townships adjoining near this line, in order that a correction could be made, also a full report made of my examination to the General Land Office.

Only field notes of the Grande Ronde Meridian, and the 6th St'd parallel south and extending west of said meridian, were furnished me.

My work was in Baker County, which is about 200 miles in length and 75 miles in breadth. I commenced work about latitude

44, and ran south, a full description of which will be given as my work progresses.

The *personnel* of my company consisted of two chainmen, a marker, a flagman, a cook, a teamster, and myself. At Boise City, Idaho, I provided myself with a heavy wagon drawn by four horses, a tent, cooking utensils, and provision to last five or six months; also necessary bedding. We left Boise City on May 4, 1883, and wended our way down the valley of Boise River, which is a very fertile valley, but sparsely settled; and the second day we reached Snake River, the boundary between Oregon and Idaho. This swift and turbulent stream, about one-half mile wide, we crossed on a ferry. It was then about sixty miles east of the point where I was to commence my labors. We were in a wild, unsettled country, rough, hilly, mountainous, stony, and rocky, destitute of timber and water, a wilderness, a treeless, God-forsaken waste. There was no one to inform me as to the location of the Grande Ronde Meridian, or how I was to get westward over the countless hills. They appeared impassable, but we knew we had to get there, so we pushed westward. We could make no calculations as to the distance we could make daily; that depended upon fuel and water. Our fuel was sage brush and grease wood, which grew from three to four feet high, the largest being not more than four inches in diameter at the root, with a broad, bushy top. The water when found was impregnated with alkali, which was not palatable. At last, by the assistance of a cow boy, we found a township corner twelve miles east of the much coveted meridian, and when we reached it, we were eighteen miles north of the 4th St'd parallel. This we re-traced till within six miles of the initial point, when we encountered the vast hills that bounded the Malheur River, — rough, rocky, steep, and treeless, and giving an impression, upon the mind of a common Michigan man, of desolation absolute. Now came the tug of war, to get our wagon and supplies down into the valley of the Malheur River, which we afterwards learned was very narrow, and the stream very swift. I instructed the teamster and cook to look for a canyon or pass through these hills into the Malheur Valley, and we would continue our course south. We soon found that it was impossible for us to keep the line of the meridian, on account of the local attraction from the basalt rock, which was very hard and flinty, and strongly impregnated with iron; — we were lost in these vast hills! About three o'clock we concluded that we would better look for our wagon. We took our back track, and, to our surprise, at dark we were obliged to camp. I had instructed our cook to fire a gun every ten minutes after six o'clock for two hours, so that we could find where he had camped. He obeyed orders, but not a sound could we hear in those everlasting hills, except the yelp of the coyote, or prairie wolf. I said we camped,

but we only stopped, because darkness compelled us to; not a drop of water near, not a morsel to eat, and not a blanket or anything to lie down upon. We built a fire with green sage brush, which we cut with a jack-knife, and tried to keep warm; but we burned upon one side while we chilled upon the other, — at least it was more comfortable to change sides. The next morning at twilight we discovered that the ground was white with frost. That was a long, dreary, hungry night, and I thought of "sweet home" in Michigan, and I thought of words some would term adjectives (but of course I did not use them) as I laid upon the cold, hard ground, with nothing but the canopy of heaven over me, turning over trying to thaw out.

About ten o'clock the next day, by the assistance of the cook's Winchester, which made the welkin ring, we found our wagon, and did full justice to pork and beans, taking our supper and breakfast together. The remainder of the day we spent in searching for a place to get our wagon down into the valley of the Malheur River. During the day we discovered what we learned afterward to be the trail made by the hundred wagons of a colony that emigrated from Missouri in 1842 to Willamette Valley in Oregon, and the ruts made by the wheels could be easily traced yet. At the point where we found our wagon, we found the remains of wagons, stoves, and cooking utensils; for these same emigrants became lost when near their journey's end, got out of provisions, and were living upon the flesh of their mules, when friends residing in the Willamette Valley searched for them and found them, and rescued them from starvation. Somewhere upon their trail they found gold in large quantities, but it had no value when they were lost, and on the eve of starvation. Several of that party have prospected for that find from year to year, but their search had been fruitless up to 1884.

When once in the Malheur Valley, we were about ten miles up stream from where we found the line of the Grande Ronde Meridian. We retraced our steps to find the point we left the night before. By diligent search, and by the aid of piles of stone which we had placed upon the highest points, we found it, and by the aid of range poles with which we had previously provided ourselves (the magnetic needle had ceased to be of any use to us, on account of local attraction), we were enabled to find the initial point, being the 4th St'd and the corner to township 20 S., between ranges 39 and 40 east, and one mile south of the Malheur River. Finding that we could not trace the meridian farther, and that our wagon was no longer available, the country being so rough and broken, I at once repaired to Malheur City, a small mining town that we had learned was about fifty miles north, ordered a new Mountain Transit with solar attachment from the well-known house of W. & L. E. Gurley, of Troy, N. Y., and purchased five ponies, one mule, and pack saddles for nine horses. The mule I rode myself, it

being much surer footed than a horse, which was of vital importance to me when climbing the steep hills and rocky peaks, in places almost impassable, that we were to encounter upon the route. Some of them were composed of shale rock which would give way under our feet, and to avoid them was next to impossible.

I had also to examine the 6th St'd parallel west for twenty-four miles, to ascertain if it was a true east-and-west line, as the error might have occurred in running it. During the time I was waiting for the arrival of my Mountain Transit with solar attachment, we employed our time in trying to trace the meridian with range poles, to see if we could discover any corners on this line; but the search was fruitless. This line for twenty-four miles was run in the fall of 1864, but the surveyors were scared out by the Bannock Indians, who were on the war-path. The work was resumed and finished in 1866. Field notes of this meridian and the 6th St'd parallel S. were furnished me, and this line was represented to be a N. and S. line, with the exception of six miles offset to the east to avoid a spur of the Blue Mountains.

In due course of time my solar came, and we ran twenty-four miles, and fell east of the township corners on meridian three chains; ran six miles farther south, found the corners well marked, and intersected what should have been the 5th St'd parallel, which I found upon investigation to start forty chains west. Thence I ran south eighteen miles; thence an offset east of six miles; thence south twelve miles to the east end of the 6th St'd parallel south. From this point seven miles south, and a half mile east, the 6th St'd parallel S. runs east, being an offset east of one-half mile. This parallel is located one mile farther south than it ought to have been, but there are no notes given of the first mile after leaving the 6th parallel. Evidently it was not measured. Here was an error of one mile south on the meridian. At one-half mile east and one mile south of 6th parallel I found the meridian, and then started south, and at a distance of twelve miles I was lost; could find no trace of the meridian. Did I say lost? I was not lost, it was the meridian; but after a search of several days, thirty chains farther south, and 6.50 chains east, I again found the meridian, and traced it south till it intersected the 7th St'd parallel S. at a distance of eighteen miles. In running this line, several errors cropped out besides the excess of about 1.28 chains. In the last eighteen miles there was about one chain to the mile excess. The west line of township 30 S. of R. 41 E. was not run by the United States Deputy Surveyor, as he reported to the Surveyor General of Oregon that he could not find the Grande Ronde Meridian, because the Indians undoubtedly had destroyed all the corners; hence this error. The south line of said township commences one mile too far south; hence another error.

Also the west line of township 32 S., R. 41 E. is one and one-half miles east from the meridian, and starts south 30 chains too

far. I found in my examination that the N. E. corner of T. 33 S., R. 41 E., extended 6.60 chains E. of the S. E. corner of T. 32 S., R. 41 E., and 30 chains south, which is a very grave error, — of course the 7th St'd parallel S. is established one mile too far south. I examined the 6th St'd parallel S. west and found it a correct line.

I examined T. 26 S. and R. 37 E., and found it had never been surveyed. I suppose that this order was to convince the authorities that ordered the survey whether I made up my field notes in the field or camp, but the result was that I was not "caught napping."

In my examination of the interior lines of T. 25 S., R. 39 E., running N. and S., when I struck the north town line, I was 40 chains west of the section corner, caused by the set-off west on the south boundary. This will produce an error in all the townships west of this. The W. half of this township never was surveyed, being exceedingly rough. A United States deputy surveyor had a contract of surveying adjoining my work. I saw him at work, and he ran east, west, south, and north in subdividing, as most convenient, hardly ever setting one-fourth post corners; never, when he did not chain.

This, after two seasons, finished my examination of the work assigned me by the Commissioner of the General Land Office, when I made a full and comprehensive report, as ordered by that office. My work was very much retarded by the errors that I found in the field. I was not able to examine more than four miles a day, on an average. Our work was a great distance from fuel and water, as there was no water excepting streams that were very few, and water standing in the pools, sinking and not to be seen again for miles. There was no timber excepting some little cottonwood along the streams, some willow, sage brush, and grasswood for fuel. A kind of bunch-grass which is very nutritious grows upon the hills and in the valleys, hence the raising of cattle and horses has been a great industry in the past, and a source of much profit; but this bunch-grass is fast being trodden and eaten out. This grass begins to start in February, and is dead and dried up by the first of July, but there being no rain or dews, retains its nutriment till new grass comes. Young cattle and horses do not have to be fed.

The streams are fed by the melting of the snow upon the mountains, and the arable lands of the valleys are irrigated by the same.

The inhabitants have to depend altogether upon irrigation, as there are no rains; and thunder and lightning are unknown. Wheat, barley, oats, and potatoes yield enormously; but the climate is too cool for corn, as it will not ripen. Wheat yields from fifty to sixty bushels per acre, which would seem to the Michigander to be incredible. Winter wheat is the only kind raised. The winters are mild, the thermometer seldom reaching zero, so it does not freeze out. Water from the ditches can be put on or taken off at

pleasure, so it is not affected by drouth. The nights are cool, which is favorable to the growth of wheat. There are no rains or winds to destroy the blossom. The heads are very long, and every place in the head has a kernel. Silica in the soil stiffens the straw so that it never lodges. The kernels are very large, plump, and heavy. Cattle and horses have to be herded, as there are no fences.

The Malheur River proper has three branches, is shallow, very wide and swift, and empties into the Snake River. Some of its fish are of the salmon species that come from the Columbia River, via the Snake. Its valleys are very narrow, fringed, and hemmed in by rugged, steep bluffs. The Owyhee is a very swift river, narrow and shallow, with steep, rugged bluffs. The Snake on the east is a very swift, boisterous river, the bottom being filled with rocks, and in consequence is not navigable; and I doubt whether any steamboat could stem the current, if free from rocks.

We saw several hot, boiling springs, and the wonder was whether caused by chemicals or internal fires. This country, no doubt, has been subject to great volcanic eruptions in ages past, as I found stone of a flinty nature that showed the effects of fervent heat, and sea shells on the highest peaks.

The climate of Eastern Oregon is very mild, all that one could wish. The nights are cool, requiring considerable covering, but in the morning one rises refreshed, and the air is balmy and bracing. No bilious diseases, no stretching and yawning, as in Michigan; one always has a good appetite as soon as out of bed. After we left Boise City, when we put up our tent to sleep in, we invited our teamster to "turn in" with us, but he declined, saying that he "preferred the pure air out doors." Before we reached the meridian, we ceased to put up our tent, and camped out till about the first of November. We had plenty of venison and antelope and jack rabbit that our cook killed with his Winchester; also trout and salmon. The boys spent their Sundays playing pedro, as we got nothing to read for weeks, being from 50 to 100 miles from a post-office. I busied myself straightening up my field notes.

Malheur City is a small mining town, and the mines that have been abandoned by the whites are worked by Chinamen. Water was brought in ditches and flumes for over 100 miles, constructed by a company from Chicago at a cost of $250,000. I became acquainted with a Chinaman, a contractor, who could speak very good English, and he gave me much valuable information about China and the Mongolian race. These Mongolians were a very industrious and inoffensive race. Notwithstanding their foul habitations, they practiced daily ablutions. They bathe as if it were a sacred duty, and in the winter they would cut holes through the ice to find the necessary water. The cue they universally wear, they regard with patriotic pride. It and the tonsure were introduced into China in 1644, as a mark of acceptance of subjection to

the Tartar rule, and enforced by the favor of the court; and those who refused to wear it were in some cases put to death. At length the mark of derision became the badge of honor, and now every Celestial carries this flag of his country, no less dear than his own head. They worship idols, and are slow to be converted to Christianity, and slow to learn to speak our language, or to understand it. Here is a specimen of some poetry, attributed to one of the Chinese scholars while being taught at a Christian mission: —

> "How doth the little busy bee
> Delight to bark and bite,
> And gather honey all the day,
> And eat it up at night."

While in Malheur City, I was asked by a United States deputy surveyor if I did not want the best cup of tea that I ever tasted. If I did, he said, just step into a Chinese restaurant, where I would get it. I consented, and after being comfortably seated at the table, I was asked if I did not want some soup. I told the waiter that I would take some, and it was so good that I took the second pint bowl, and I thought it the best soup I had ever tasted. After leaving, the deputy asked me how I liked the soup, and informed me that it was rat soup. "Yes, made of rats!" he said with emphasis, and about then and there my stomach heaved and rolled, while my friend tried to console me by saying that I had eaten more filthy things than this; for illustration, the dung-hill fowl and the hog. The illustration was well taken, but that did not settle my stomach. It required time, and it brought to my mind the story of the old lady who said, as she kissed the cow, "It is just as one is brought up."

These Chinamen who were digging for gold found the tooth of a mastodon, that weighed four pounds. It was ten feet from the surface, in gravel, in a good state of preservation, and had to all appearance lain there for ages. The climate of Eastern Oregon was all that one could desire, — days not overly hot, very temperate, the nights cool, requiring considerable covering, no mosquitoes, no reptiles. The air is pure and exhilarating, and it is a pleasure before sunrise to inflate the lungs with this pure air; but one has to be careful, if his vest is buttoned up tight, that he does not in a thoughtless moment burst the buttons off.

During the examination, before the arrival of my solar, as we were riding in single file, some cow-boys from a ranch about three miles distant discovered us in the distance, and also seeing me seated upon my mule upon a peak about 500 hundred feet high, "taking the country in," they took me to be the "big Injun," watching the movements of the whites. They reported to the settlers about twenty miles west of us that there were Indians in the country, and that they would better fly for safety. In the excitement, they left everything, and went to a fort that had been

built by Uncle Sam upon the Malheur Indian Reservation, the Indians having been removed previously. Men well armed came to watch the movements of "the Indians," but they were sure to keep their distance, so as to be doubly safe. One evening, two of my employees went to the ranch before mentioned to get some buttermilk, and to their astonishment found two cow-boys armed with Winchesters, standing as sentinels or guards, while several inside were eating supper with Winchesters at their sides. They informed the boys that there were Indians prowling about, and that they were liable to be attacked and massacred at any time. When they had fully explained what they had seen, and the boys had informed them that it was a company of surveyors that they had seen, they were surprised, and could hardly be made to believe it. They intended that night to make a raid upon us, and probably some of us would have been made to "bite the dust." Had it not been for buttermilk some of us would have gone "where the woodbine twineth." This occurrence made some of my boys timorsome, as they said the Indians might be lurking around, for aught we knew. This Indian scare even crept into the newspapers, but the truth of the matter did not get there. When the truth of the scare was reported at the fort, the settlers returned to their homes.

One day while riding horseback, I saw in the distance what appeared to be a city with its lofty spires. On approaching it, I found it to be a very curious formation, standing out in the valley of the Malheur River in bold relief from the surrounding bluffs, several hundred feet high, composed of several layers of sandstone, chalk, and basalt rock, and having been worn into almost every shape that the imagination might picture, by floods and stormy weather, and the hand of time had carved it into the most curious and fantastic forms, lofty domes, pinnacles, and fluted columns, resembling at a distance the ruins of an ancient city or cathedral in the midst of general desolation.

Having received a telegram from the General Land Office to report at Valentine, Neb., for duty, I then left Oregon; but I will say that on my way, crossing Snake River, a bridge was being built by the Oregon Short Line, having three abutments sixty feet high, the center one being very difficult of construction, as the river was so swift. They were constructed of cut stone shipped from Cleveland, Ohio. The bridge was to be built of iron, but the chief engineer of construction, who had been chief during the construction of the Union Pacific, had made a mistake of one foot in length of one span, which delayed the construction for some time. That engineer was informed that his services were no longer wanted.

I arrived at Valentine, a place of 600 inhabitants, situated upon, and at the then terminus of, the Sioux City and Pacific R. R., west of Omaha, Neb., 300 miles. There I found instructions to provide

myself with the necessary outfit and reliable men, whom I would better arm well, and proceed at once to northwest Nebraska, giving the township ranges, etc., 200 miles distant, to make an accurate survey of all inclosures by wire fence and otherwise, of Government lands by cattle-men, and also to examine all fraudulent entries, homesteads, preemptions, etc., as it had been reported to that office that Government lands were being unlawfully fenced in by cattle-men, and fraudulent entries made, and that homesteaders and preemptioners were being "frozen out," or forcibly ejected, if they attempted to settle within the inclosures. At the close, I was to make a clear and explicit report of the result of my examination. The United States deputy surveyor, who had the season before surveyed that country, had cut the wire fences to allow the teams to pass, and had let the cattle-men's stock away, requiring much time and expense to recover them. By so doing, the deputy surveyor had incurred their displeasure, and they had placed notices upon the fences, "Death to the son-of-a-bitch that again cuts our wire fences." Hence the order from the Department to arm my men to fight. I had not enlisted to fight, — no bounties were offered, — but having learned the character of cattle men and cow-boys while in Oregon, I preferred to adopt the pacific course, and I found that it won. The latch string of the cabin I ever found hanging on the outside of the cabin door, and the inmates were always ready to give us any information desired, and to give us shelter or anything we needed.

I hired a man, with a wagon and four good horses, who acted as teamster and cook, and three other men, two chainmen and a flagman; bought a tent, stove, and provisions to last us the round trip. We took along about forty bushels of corn to feed our teams, started out on October 6, 1884, and reached Pine Ridge, Indian Agency, 120 miles distant, on the 12th (the country unsettled), just over into the southern part of Dakota. Dr. Mc Gillicuddy, agent, received us kindly, and entertained us very pleasantly, giving me some really valuable information about the character of the Sioux Indians. He pointed out to me the Indian chief that claimed to have killed Gen. Custer. He was a sour, coarse, revengeful-looking being, painted, wearing feathers on his head, and beads, cheap jewelry, etc., on different parts of his person; calico shirt, blanket, buckskin leggings, and moccasins. He informed me that there were about 7,000 Indians, old and young. The Government clothes and feeds them. They consume the beef of over 6,000 three-year-old steers yearly. The Indians kill and dress the beef, and it is then dealt out by the Commissary. The Indians are well fed, having in addition, flour, sugar, coffee, yeast, salaratus, and even soap, and the necessary cooking utensils. At this Agency there is a police force of 100 Indians, well armed, drilled, and dressed in Uncle Sam's uniform, and paid by that gentleman. There are also two schools here to teach them to read, write, cook,

and sew, taught by two maidens from Chicago. I spent half a day in the school, and it was amusing to see the proficiency they made in making pictures, but they were slow in learning our language, hence slow to learn to read and to spell. Several have been sent to Carlisle, Pa., to school, but the confinement did not agree with them, and they often returned with consumption, and soon died.

The Government furnished these Sioux with 500 new wagons and double harnesses, and they broke their ponies and drew their flour and groceries from Valentine at $1.25 per hundred, and the Government paid them for it. Some of them dressed like white men. When I was there, 6,000 steers were delivered by contractors at five cents per pound, to a United States Officer (Captain) in the regular army, and weighed, averaging 1,000 lbs. each. McGillicuddy was afterwards accused, upon pretty good authority, of manipulating the scales so as to make each steer weigh 25 pounds heavier, which would make 150,000 pounds gain, and at 5 cents a pound would amount to $7,500, which was pocketed by the agent and seller; but inasmuch as it came out of Uncle Sam, it was all right.

Congress sent a committee of seven members of Congress to investigate the several Indian agents in the northwest, and while investigating this Agency, taking testimony, etc., one Indian contradicted another. The lie passed, and tomahawks were raised and knives drawn, and for a few minutes an outbreak seemed imminent, but McGillicuddy rushed in bravely and quelled the seeming outbreak. It was said that McGillicuddy told the committee that his timely interposition saved an outbreak, and had there been one at that time, not a white would have been left to tell the story. The next morning that committee left the business they were expected to finish. When they arrived at Valentine, I talked with several members of the commission, and from the tone of their talk they believed that they had barely escaped with their scalps. I talked with Holman, Chairman of the Commission, who was from Indiana. He is rather small in stature, aged about 65 years, and is known in Congress as the "Chronic Objector," as he will not allow any bills to come up unless in regular order. He said that he slept with both eyes "wide open," after he saw those tomahawks and long knives gleam in the air. The old man was evidently scared. They all thought their time had come. I never learned what they reported in this special case to Congress, but I think that they were evidently "sold out" cheap.

While visiting this reservation, Dr. McGullicuddy took me to some Indian tents. There I saw squaws at work dressing or preparing buffalo-robes for market. He informed me that when these hides were first taken from the animals, they must be stretched and dried flesh side up. If not in this condition, when the squaws received them they have to do it. After they are thoroughly dried, the squaws take all the flesh off and reduce

them to an even thickness with an instrument, which for want of a better name, may be termed an adz. It was a little thin piece of iron about two inches long on the edge, and two and one-half inches deep. This was firmly tied to a piece of the thigh bone of an elk, and was used the same as a garden hoe. When the required thickness was obtained, the flesh side was covered with a preparation of lard, soap, and salt, and the robe was then rolled up and laid by for two or three days. It has then to be unrolled and again stretched on a frame like a quilt, with the flesh side to the sun. In this shape it was scraped with a thin oval-shaped piece of iron or steel, resembling a kitchen chopping-knife without the handle; this process usually lasted about two days. The robe was then taken from the frame, and drawn across a rope until it became thoroughly dry and soft. This last process made it very pliable, but required a good deal of time and strength; but it rendered the robe ready for market. I bought a very large one, costing eleven dollars. I brought it home and could have sold it for forty dollars. The squaws laughed when I pulled out my note book and began to write, being evidently as much astonished and interested as I was. They looked with wonder at the book, pencil, and the words I wrote. The lazy bucks just stood and looked on, while evidently the squaws always did the work, were willing to do it, and the Indians willing that they should. An Indian is constitutionally opposed to labor. He is evidently "tired" all the time. It is my opinion that the Indians will never make farmers, dividing their lands in severalty and breaking up their tribal relations will be a failure. But this is a problem yet to be solved, and it has been the study of the best minds in the nation for years.

After we left the Agency, the first night that we camped we saw about a dozen squaws with a span of ponies and a wagon without any box upon it, only a few boards. They were gathering some kind of berries, but their team balked coming down the hill. Not a step would they take downward. The squaws hollowed, and yelled, and whipped, and tried to push them down hill, but they would only push backwards (the first time I ever saw horses balk coming down hill). I sent my boys, and told them to unhitch the team from the wagon and draw it down. They did so, and the squaws laughed and showed their appreciation as best they could. They camped near us, and used water from the spring. The next morning they had their breakfast before we did, and a young squaw, probably eighteen years of age, her hair nicely braided and her head and face painted, and dressed in a sort of blue woolen Indian cloth, with beads around her neck, and brass finger rings on her fingers, in company with her mother, paid our camp a visit while we were eating breakfast, and stood around our camp fire. This young maiden watched the boys, and after breakfast she, by direction of the old lady, handed each some berries, when the old lady laughed and seemed very much pleased.

What they meant by this we could not conjecture, unless it was Indian love. We left that morning, "Westward, Ho!" and arrived that night at Camp Robinson, where about 1,000 United States troops were stationed to watch Indians.

On the 16th of October, we were in Hot Creek Valley, a distance of 200 miles west of Valentine, where I found six inclosures, averaging from 5,000 to 25,000 acres, and pasturing from 400 to 1,000 horses, and from 5,000 to 15,000 head of cattle each; but they pastured the surrounding country, only keeping these inclosures for their riding horses and the fat cattle that were to be sold. I then went south over a spur of the Black Hills, about twenty miles on to the Niobrara River, and surveyed around a ranch that contained 62,000 acres in its inclosure, and was forty-five miles around it. We had to camp on one side of the river, where we could get wood and water. It took us ten days, and as we were obliged to travel from ten to fifteen miles each day to our work, we took a team. We borrowed dry pine wood of the owners of the ranch, who had to draw it fifteen miles from a spur of the Black Hills. This company, of which A. S. Hewitt, of New York City, was president, had 16,000 head of cattle and 1,500 head of horses. This ranch bordered on and extended into Wyoming. Ten miles from this, down the valley of Niobrara River, they had another ranch of 16,000 acres; they had very good buildings upon all these ranches, built of pine logs taken out of the Black Hills, which were timbered with pine, and would afford plenty of timber and lumber for the surrounding country for years. The land was generally prairie, which raised a great amount of grass; and the pasturage was rich, but in many places the water was impregnated with alkali. The country was well watered with good springs and brooks, and I think, all things considered, is the best part of Nebraska.

During the summer of 1885, nearly this whole country was preempted and homesteaded, and by order of the General Land Office, the wire fences had to be taken down, and then there was an emigration to Montana, to "other pastures new." In the fall of 1886, the Sioux City & Pacific R. R. had extended their road from Valentine west up the valley of the Niobrara River, and built a depot where we camped at the A. S. Hewitt ranch.

We found many fraudulent preemptions by employees of these cattle-men, that I prevented from proving up at the Land Office at Valentine, being in that land district, and being located some six months at Valentine. I prevented many frauds on Government lands.

We found in one place, called the "Bad Lands," that the ground in the spring was so soft that it was impassable with wagons, and nearly so on horse-back, being of a clayey nature, soft and sticky, and said to load the wheels down in going a short distance, so that the wagon could not be moved. It would shake

like liver, but in the summer it became hard. Petrified frogs, mud-turtles, and fish were numerous. I saw a petrified mud-turtle that weighed 25 lbs. I also saw hundreds of the heads of buffaloes which had probably been killed by the Indians, but I saw none alive. They are of the past, — have followed in the wake of the mastodon.

I think that most of the land passed over by me is better adapted to raising stock than grain, as the elevation is too great for corn. Good wheat has been raised, and no country excels it in raising potatoes, barley, and oats.

Wild game is plenty, such as deer, antelope, wild geese, ducks, prairie chickens, and grouse, and the streams abound with excellent fish.

I finished my examination on the 20th of November, and turned my face toward Valentine. The weather had become cold and disagreeable to camp out. We were just one month too late, and on the morning of the 24th, six inches of snow laid upon the ground, and the thermometer was 12° below zero. Then we appreciated our tent and stove. We arrived at Valentine, Dec. 31, well satisfied that we could now appreciate comfortable quarters.

ISAAC TELLER.

Mr. Appleton. — "Are these river valleys generally fenced in?"

Mr. Teller. — "No, sir, they are not. The valleys are generally very narrow."

Mr. Appleton. — "Each valley, then, would have but one owner, would it?"

Mr. Teller. — "In some cases it had several owners."

Mr. Appleton. — "Are these valley ranches large? Are they not generally owned by poor people?"

Mr. Teller. — "Yes, sir, generally owned by poor people. The lands in those valleys are extremely rich and fertile."

Mr. Appleton. — "Have they any legal claim on the land?"

Mr. Teller. — "They are mostly homesteaders."

Mr. Appleton. — "They have no schools, have they?"

Mr. Teller. — "No, sir."

Mr. Appleton. — "Where did you find the pine?"

Mr. Teller. — "In northwestern Oregon. The geological aspect of the country looks as though it had been thrown up at some time. I found shells that were carried there from the sea. The air was very pure, and you could look upon the mountains a hundred miles distant, and sometimes we saw the mirage. At one place when I was traveling on horse-back one day, I saw in the distance what appeared like a city, but come to get up to it, it was columns of basalt, which looked like church spires."

STEEL TAPES.

It doubtless may be a matter of some interest to surveyors to see a comparison of the steel tapes sold as accurate measures, with a standard United States measure.

The standard in question is a brass yard of a certain number, furnished our State by the Treasury Department at Washington, as a standard yard. It is of exact length, at a temperature of 58.4° F., and is both a line and end measure.

The tapes in question were kept in the same room with the standard for some time, and were of the same temperature as the standard when making the test.

Three tapes were tested, No. 1 being an English tape, with graduations etched on the steel. No. 2 was graduated by soldering on babbit metal, and stamping the graduation on that. No. 3 is a tape graduated by puncturing holes through the body of the tape, and putting a rivet through at every point.

The report of my assistant, showing how the tapes were calibrated, is respectfully submitted. Yours,

R. C. Carpenter.

The accuracy of three different makes of steel tapes was tested as follows, with regard to graduation, calibrating them with a United States standard yard measure: The method of making the test was to have a person hold the back end of the tape exactly at the mark, while another exerted a strain of ten pounds on the tape, and a third person noted the variations. We were able to test only forty-five feet of the tape No. 1, owing to a break just beyond the forty-fifth foot. The following tables will show the variation for each foot in decimals of one inch.

TABLE SHOWING VARIATION OF THE NO. 1 STEEL TAPE.

Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.
1	+ .035	13	+ .05	24	+ .03	35	+ .01
2	+ .04	14	+ .04	25	+ .03	36	+ .005
3	+ .06	15	+ .05	26	+ .025	37	+ .005
4	+ .06	16	+ .05	27	+ .02	38	+ .005
5	+ .06	17	+ .05	28	+ .03	39	.000
6	+ .05	18	+ .04	29	+ .03	40	.000
7	+ .06	19	+ .04	30	+ .03	41	— .005
8	+ .07	20	+ .035	31	+ .035	42	— .01
9	+ .06	21	+ .03	32	+ .025	43	— .01
10	+ .065	22	+ .035	33	+ .01	44	— .01
11	+ .07	23	+ .04	34	+ .01	45	— .015
12	+ .05						

The length of No. 1 Tape is 44 feet 11.985 inches; temperature, 70° F. Total error, .015 inches.

TABLE SHOWING THE VARIATION OF THE NO. 2 STEEL TAPE.

Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.
1	+ .02	14	— .01	27	+ .00	39	— .01
2	+ .01	15	— .01	28	.00	40	— .01
3	.00	16	— .01	29	.00	41	— .02
4	.00	17	.00	30	.00	42	.00
5	— .03	18	.00	31	.00	43	.00
6	— .03	19	+ .01	32	+ .01	44	+ .01
7	— .02	20	+ .01	33	.00	45	+ .02
8	— .02	21	.00	34	.00	46	+ .02
9	— .02	22	.00	35	.00	47	+ .02
10	— .03	23	+ .01	36	.00	48	.00
11	— .03	24	.00	37	.00	49	.00
12	— .03	25	+ .01	38	.00	50	— .01
13	— .02	26	+ .01				

The length of No. 2 Tape is 49 feet 11.99 inches; temperature, 70° F.

TABLE SHOWING THE VARIATION OF THE NO. 3 STEEL TAPE.

Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.
1	— .04	14	— .055	27	— .200	39	— .190
2	— .05	15	.065	28	— .230	40	— .240
3	— .03	16	— .105	29	— .200	41	— .290
4	— .05	17	.065	30	— .220	42	— .210
5	— .03	18	— .095	31	— .270	43	— .230
6	— .05	19	— .095	32	— .220	44	— .250
7	— .01	20	— .135	33	— .220	45	— .260
8	— .05	21	— .155	34	— .220	46	— .260
9	— .05	22	— .155	35	— .240	47	— .260
10	— .09	23	— .155	36	— .230	48	— .250
11	— .10	24	— .155	37	— .170	49	— .270
12	— .055	25	— .205	38	— .180	50	— .390
13	— .055	26	— .235				

The length of No. 3 Tape is 49 feet 11.61 inches; temperature, 70° F.

Respectfully submitted,

O. C. Hollister.

SUPREME COURT DECISIONS.

The following abstract of Supreme Court Decisions is compiled from the "American Digest," and published by permission of the West Publishing Co., of St. Paul, Minn.: —

Where there is a dispute as to the true division line between adjoining proprietors, and they agree on a permanent boundary, and take possession accordingly, the agreement is binding on them, and those claiming under them; and such agreement is not within the statute of frauds. — *Following Jacobs vs. Moseley, 4 S. W. 135; Aichison vs. Pease (Mo.), 10 S. W. 159.*

In ascertaining the boundaries of a city lot bordering on a street, the lines of the street as located by the city engineer, and acquiesced in by the city authorities and the public for many years, are to be preferred to those of a more recent survey. — *Koenigs vs. Jung (Wis.), 40 N. W. 801.*

In taking distances from one point to another on navigable water, the measurement is by its meanders, and not in a direct line. — *Rayburn vs. Winant (Or.), 18 Pac. 588.*

Where there are well-established monuments of a boundary, and the line run from the point of beginning by courses and distance does not conform to one of the natural calls, whereas by starting from the other point, all the natural calls are answered, the first course and distance from the point of beginning must give way, especially when by following it the line is taken out in an open valley where there is no apparent reason for its frequent changes of course, but taken the other way it runs along the base of mountains, which render such changes necessary. — *Hughes vs. Cawthorn, 35 F. 248.*

The Government plat and field notes described the meander line of a tract of land as being at the Missouri River. In fact, the meander line was not run along the river, but along a bayou, some distance from the river; and land between the bayou and the river, though in existence at the time of the survey, had never been surveyed. *Held*, that such land did not pass by a conveyance from the government of the surveyed tract. — *Glenn vs. Jeffrey (Iowa), 39 N. W. 160.*

A patent conveyed the west fraction of a fractional quarter-section containing 23.10 acres. West of such land was a large running slough, or navigable arm of the Mississippi River. In the Government survey of the fractional quarter, a meander line was run along the east bank of the slough, but was not marked on the Government plat. The slough was marked on the map as the west boundary of the land. *Held*, that the meander line was not a boundary, and that the patent included an island lying between

the land described and the middle of the slough, such island never having been surveyed or platted by the general Government. — *Fuller vs. Dauphin (Ill.), 16 N. E. 917.*

A Government "lot" was platted as bounded on the north by a meandered water-course, whose actual shore line was about 320.6 feet north of the meandered line, the lot being merely described as numbered on the plat. *Held*, that its east line ran due north until it intersected the actual shore line, and thence to the middle thread of the stream, at right angles with such thread, and did not turn at its point of intersection with the meander line; the latter line being run, not as a boundary, but merely to determine the number of acres in the lot. — *Menasha Wooden-Ware Co. vs. Lawson (Wis.), 36 N. W. 412.*

Where it appears that a street was originally laid out 23 feet in width, and that it is that width except at the place of plaintiff's alleged encroachment of 23 inches, and that certain trees cut down inside plaintiff's fence were at one time outside a narrow pavement used by the city, and that plaintiff's lot contains all his deed calls for, without said 23 inches, the line as claimed by the city is sufficiently established. — *Yates vs. Town of Warrenton (Va.), 4 S. E. 818.*

Where the dispute is as to whether a certain fence or an adjacent ditch is the division line, it is error to admit the testimony as to what witness supposed, or what was generally supposed, to be the line, though witness had been long and intimately acquainted with the premises. — *Beecher vs. Galvin (Mich.), 39 N. W. 469.*

The statement of a witness that the ditch was acquiesced in as the dividing line between the predecessors in estate of the parties litigant; that it was tacitly consented to by all parties for the reason that no one ever obstructed, or put a fence in the ditch, is inadmissible as being the witness's conclusion. — *Idem.*

A deed conveyed certain lands, "excepting and reserving therefrom 68 feet of land off from the east end of said described premises." The vendor retained possession of a lot 68 feet wide, along the whole east side of the lands, and put the purchaser in possession of the remainder. They built a fence and dug a well on the line thus fixed. The vendor built a house and barn on the portion held by him, and after many years, conveyed it, as 68 feet wide. *Held*, from the acts of the parties, and the surrounding circumstances, that the exception was meant to reserve 68 feet in width along the east end of the lot, and not 68 feet, which would be a strip but six inches wide. — *Montfort vs. Stevens (Mich.), 35 N. W. 827.*

Plaintiff claimed title under a survey by the United States in 1868, and a certificate of purchase from the State describing the

land as in section 18. Defendant showed that the first survey proving incorrect, a new survey was made in 1880, when defendant made a homestead entry upon the land then described as N. W. ¼ section 17. *Held*, that as plaintiff had never been in actual possession of the land, nor had it been listed to the State when he purchased, nor prior to the second survey, the title would follow the second survey. — *Murphy vs. Sumner (Cal.), 16 Pac. 13.*

When, in the description in a deed, reference is made to a plat, it may be used to identify the lands referred to, though it does not conform to the statute, and is not duly certified. — *Sanborn vs. Mueller (Minn.), 35 N. W. 666.*

Where, in an office survey, a line was described as running from a fixed point south to another point described, but not established on the ground, which did not lie in the designated course, it being intended that the line should run north and south, *held*, that the second point named being descriptive, and not locative, should be disregarded, and that the line should follow the course named. — *Lilley vs. Blum (Tex.), 6 S. W. 279.*

In 1847, adjoining lots 51 and 54 were conveyed according to a survey and recorded plat. In 1884, a street having been laid through lot 54, the owner subdivided and recorded a plat of that part of lot 54 between lot 51 and the street, and conveyed the land in question to defendants, who took possession, and in good faith erected buildings thereon. In this survey, a line was established as the true line between lots 51 and 54, as located by the original survey, by following the lines of an old fence shown to have been treated for more than thirty years as the line of the original survey, and regarded as the division line for more than fifteen years, improvements having been made up to this fence. This line corresponded with the fences on adjoining lots, and showed a shortage in the calls and distances of the original plat. Plaintiff's subsequent resurvey started from a line assumed as one of those in the original survey without evidence that it was, and ignoring all fences and following the courses and distances marked on the plat, overlapped the line established by defendant. *Held*, that the line established by defendant must be regarded as the true one. — *Beaubien vs. Kellogg (Mich.), 37 N. W. 691.*

Under How, St., Mich., § 622, providing that county surveyors, in locating extinct interior section corners, shall re-establish them at proportional distances, as recorded in the original field notes, from the nearest known points in the original section lines east and west, north and south, from such extinct corner, a section corner on a town line should be located by lines run from the nearest known Government monuments east and west on the township line, and not by measuring from one known quarter section corner north to one south of the line, and dividing the distance. — *Hess vs. Meyer (Mich.), 41 N. W. 422.*

Under such statute the record of the survey, when made pursuant to its provisions, is receivable in evidence to show the true location of the corners, but the surveyor's work is not *prima facie* correct, and to so instruct is error. — *Idem.*

Though the statutes of Michigan authorize a board of supervisors to direct a surveyor to locate lost corners, and to return his survey, and cause it to be recorded, in which case the record shall be competent evidence to establish the corners, if he makes the survey without causing it to be recorded, it is error to allow the fact of his authority to make it to be proved in a case in which he has testified as to the location of the corners, as the jury might infer that his acts were official, and give his testimony undue weight for that reason. — *Idem.*

In this case, when formerly here, the map of the original survey was not so certified as entitled it to be received in evidence, and there was nothing in the case as then presented that showed that the premises described in the declaration came within the description of the S. E. ¼ of section 28. In the record before us this has been obviated, and the copy of the original plat of the township has been introduced, which shows according to the Government survey that the premises in question are embraced in what the Government denominated the S. E. fractional ¼ of section 28 in its patent to Lingley. It might perhaps have been more accurate to describe it as that portion of section 28 lying south of Black River; but as the fraction contained less than 160 acres, and the law required it to be sold entire, the description contained in the patent was sufficient, and is quite a customary method of description in the General Land Office. The conclusion of law which the court below arrived at — so far as it holds that under the facts of this case as now disclosed, the premises claimed are not contained in the claim embraced in the declaration — is erroneous. — *Wilson vs. Hoffman, 38 N. W. Rep. 558.*

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